REPORT

OF THE

SEVENTY-FIFTH MEETING OF THE

BRITISH ASSOCIATION

FOR THE ADVANCEMENT OF SCIENCE

SOUTH AFRICA

AUGUST AND SEPTEMBER

1905

LONDON
JOHN MURRAY, ALBEMARLE STREET
1906

Office of the Association: Burlington House, London, W.

PRINTED BY
SPOTTISWOODE AND CO. LTD., NEW-STREET SQUARE
LONDON

CONTENTS.

REPORTS ON THE STATE OF SCIENCE.

TRANSACTIONS OF THE SECTIONS.

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*[An asterisk * indicates that the title only is given. The mark † indicates the same, but with a reference to the Journal or Newspaper in which it is published* in extenso.]

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

CAPE TOWN.

WEDNESDAY, AUGUST 16.

THURSDAY, AUGUST 17.

FRIDAY, AUGUST 18.

JOHANNESBURG.

TUESDAY, AUGUST 29.

WEDNESDAY, AUGUST 30.

FRIDAY, SEPTEMBER 1.

SECTION B.—CHEMISTRY.

CAPE TOWN.

WEDNESDAY, AUGUST 16.

THURSDAY, AUGUST 17.

FRIDAY, AUGUST 18.

JOHANNESBURG.

TUESDAY, AUGUST 29.

SECTION D.—ZOOLOGY.

CAPE TOWN.

WEDNESDAY, AUGUST 16.

THURSDAY, AUGUST 17.

FRIDAY, AUGUST 18.

Johannesburg.

TUESDAY, AUGUST 29.

WEDNESDAY, AUGUST 30.

FRIDAY, SEPTEMBER 1.

Section G.—ENGINEERING.

Cape Town.

WEDNESDAY, AUGUST 16.

THURSDAY, AUGUST 17.

FRIDAY, AUGUST 18.

JOHANNESBURG.

TUESDAY, AUGUST 29.

WEDNESDAY, AUGUST 30.

FRIDAY, SEPTEMBER 1.

SECTION H.—ANTHROPOLOGY.

CAPE TOWN.

WEDNESDAY, AUGUST 16.

THURSDAY, AUGUST 17.

FRIDAY, AUGUST 18.

JOHANNESBURG.

TUESDAY, AUGUST 29.

WEDNESDAY, AUGUST 30.

FRIDAY, SEPTEMBER 1.

Section I.—PHYSIOLOGY.

CAPE TOWN.

WEDNESDAY, AUGUST 16.

THURSDAY, AUGUST 17.

FRIDAY, AUGUST 18.

Johannesburg.

TUESDAY, AUGUST 22.

WEDNESDAY, AUGUST 30.

FRIDAY, SEPTEMBER 1.

Section K.—BOTANY.

Cape Town.

WEDNESDAY, AUGUST 16.

Section L.—EDUCATIONAL SCIENCE.

Cape Town.

WEDNESDAY, AUGUST 16.

APPENDIX.

LIST OF PLATES.

OBJECTS AND RULES

OF

THE ASSOCIATION.

OBJECTS.

The Association contemplates no interference with the ground occupied by other institutions. Its objects are:—To give a stronger impulse and a more systematic direction to scientific inquiry,—to promote the intercourse of those who cultivate Science in different parts of the British Empire, with one another and with foreign philosophers,—to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress.

RULES.

Admission of Members and Associates.

All persons who have attended the first Meeting shall be entitled to become Members of the Association, upon subscribing an obligation to conform to its Rules.

The Fellows and Members of Chartered Literary and Philosophical Societies publishing Transactions, in the British Empire, shall be entitled, in like manner, to become Members of the Association.

The Officers and Members of the Councils, or Managing Committees, of Philosophical Institutions shall be entitled, in like manner, to become Members of the Association.

All Members of a Philosophical Institution recommended by its Council or Managing Committee shall be entitled, in like manner, to become Members of the Association.

Persons not belonging to such Institutions shall be elected by the General Committee or Council to become Life Members of the Association, Annual Subscribers, or Associates for the year, subject to the approval of a General Meeting.

Compositions, Subscriptions, and Privileges.

Life Members shall pay, on admission, the sum of Ten Pounds. They shall receive *gratuitously* the Reports of the Association which may be published after the date of such payment. They are eligible to all the offices of the Association.

Annual Subscribers shall pay, on admission, the sum of Two Pounds, and in each following year the sum of One Pound. They shall receive

gratuitously the Reports of the Association for the year of their admission and for the years in which they continue to pay *without intermission* their Annual Subscription. By omitting to pay this subscription in any particular year Members of this class (Annual Subscribers) *lose for that and all future years* the privilege of receiving the volumes of the Association *gratis;* but they may resume their Membership and other privileges at any subsequent Meeting of the Association, paying on each such occasion the sum of One Pound. They are eligible to all the offices of the Association.

ASSOCIATES for the year shall pay on admission the sum of One Pound. They shall not receive *gratuitously* the Reports of the Association, nor be eligible to serve on Committees, or to hold any office.

The Association consists of the following classes:—

1. Life Members admitted from 1831 to 1845 inclusive, who have paid on admission Five Pounds as a composition.

2. Life Members who in 1846, or in subsequent years, have paid on admission Ten Pounds as a composition.

3. Annual Members admitted from 1831 to 1839 inclusive, subject to the payment of One Pound annually. [May resume their Membership after intermission of Annual Payment.]

4. Annual Members admitted in any year since 1839, subject to the payment of Two Pounds for the first year, and One Pound in each following year. [May resume their Membership after intermission of Annual Payment.]

5. Associates for the year, subject to the payment of One Pound.

6. Corresponding Members nominated by the Council.

Subscriptions shall be received by the Treasurer or Secretaries.

Members and Associates will be entitled to receive the annual volume of Reports, *gratis*, or to *purchase* it at reduced (or Members') price, according to the following specification, viz.:—

1. *Gratis.*—Old Life Members who have paid Five Pounds as a composition for Annual Payments, and previous to 1845 a further sum of Two Pounds as a Book Subscription, or, since 1845, a further sum of Five Pounds.

   New Life Members who have paid Ten Pounds as a composition.

   Annual Members *who have not intermitted* their Annual Subscription.

2. *At reduced or Members' Price*, viz., two-thirds of the Publication Price. —Old Life Members who have paid Five Pounds as a composition for Annual Payments, but no further sum as a Book Subscription.

   Annual Members who have intermitted their Annual Subscription.

   Associates for the year. [Privilege confined to the volume for that year only.]

3. Members may purchase (for the purpose of completing their sets) any of the volumes of the Reports of the Association up to 1874, *of which more than* 15 *copies remain*, at 2*s*. 6*d*. per volume.[1]

Application to be made at the Office of the Association.

Volumes not claimed within two years of the date of publication can only be issued by direction of the Council.

[1] A few complete sets, 1831 to 1874, are on sale at £10 the set.

Meetings.

The Association shall meet annually, for one week, or longer. The place of each Meeting shall be appointed by the General Committee not less than two years in advance;[1] and the arrangements for it shall be entrusted to the Officers of the Association.

General Committee.

The General Committee shall sit during the week of the Meeting, or longer, to transact the business of the Association. It shall consist of the following persons:—

CLASS A. PERMANENT MEMBERS.

1. Members of the Council, Presidents of the Association, and Presidents of Sections for the present and preceding years, with Authors of Reports in the Transactions of the Association.

2. Members who by the publication of Works or Papers have furthered the advancement of those subjects which are taken into consideration at the Sectional Meetings of the Association. *With a view of submitting new claims under this Rule to the decision of the Council, they must be sent to the Assistant Secretary at least one month before the Meeting of the Association. The decision of the Council on the claims of any Member of the Association to be placed on the list of the General Committee to be final.*

CLASS B. TEMPORARY MEMBERS.[2]

1. Delegates nominated by the Corresponding Societies under the conditions hereinafter explained. *Claims under this Rule to be sent to the Assistant Secretary before the opening of the Meeting.*

2. Office-bearers for the time being, or delegates, altogether not exceeding three, from Scientific Institutions established in the place of Meeting. *Claims under this Rule to be approved by the Local Secretaries before the opening of the Meeting.*

3. Foreigners and other individuals whose assistance is desired, and who are specially nominated in writing, for the Meeting of the year, by the President and General Secretaries.

4. Vice-Presidents and Secretaries of Sections.

Constitution of the Sectional Committees.[3]

(i) The President, Vice-Presidents, and Secretaries of a Section are appointed by the Council in November or December. They form, with the existing members (see (ii) and (vi)), the Committee, which has the duty of obtaining information upon the Memoirs and Reports likely to be submitted to the Section at the next meeting, of preparing a report thereon, of generally organising the business of the Section, and of bringing before the Council any points which they think deserving of consideration.[4]

[1] Revised by the General Committee, Liverpool, 1896.

[2] Revised, Montreal, 1884.

[3] Adopted by the General Committee at Cambridge, 1904.

[4] *Notice to Contributors of Memoirs.*—Authors are reminded that, under an arrangement dating from 1871, the acceptance of Memoirs, and the days on which

(ii) The Sectional Presidents of former years are *ex-officio* members of these Committees.

(iii) The Sectional Committees may hold such meetings as they think proper for the organisation of the business, but shall, under any circumstances, meet on the first Wednesday of the Annual Meeting at 2 P.M. for the appointment of additional Members and other business.

Any member who has served on the Committee in previous years, and who has intimated his intention of being present at the Meeting, is eligible for election as a Member of the Committee at its first meeting.

(iv) The Sectional Committees shall have power to add to their number from day to day during the Annual Meeting, but it is not desirable for them to be larger than is necessary for efficiency; they have also the power to elect not more than three Vice-Presidents at any time during the meeting, in addition to those appointed by the Council.

(v) The List formed during the Annual Meeting is to be entered daily in the Sectional Minute-Book, and a copy forwarded without delay to the Printer, who is charged with publishing the same before 8 A.M. on the next day in the Journal of the Sectional Proceedings.

(vi) Before the close of the Annual Meeting each Sectional Committee is to nominate six members of the Association to form the nucleus of the Committee for the succeeding year, and forward a list of the six names to the Assistant Secretary of the Association.

Included in the six names should be the existing President of the Section, or one of the Vice-Presidents, and one of the existing Secretaries.

It will be the duty of these Members to transact the business of the Committee until the officers of the Section for the ensuing year are appointed by the Council, and thus become the officers of the Committee (see (i)).

Business of the Sectional Committees.

Committee Meetings are to be held on the Wednesday, and on the following Thursday, Friday, Saturday (optional), Monday, and Tuesday, for the objects stated in the Rules of the Association. The Committee of a Section is empowered to arrange the hours of meeting of the Section and the Sectional Committee.

The business is to be conducted in the following manner:—

At the first meeting, one of the Secretaries will read the Minutes of last year's proceedings, as recorded in the Minute-Book, and the Synopsis of Recommendations adopted at the last Meeting of the Association

they are to be read, are now as far as possible determined by the Sectional Committees *before the beginning of the Meeting.* It has therefore become necessary, in order to give an opportunity to the Committees of doing justice to the several Communications, that each author should prepare an Abstract of his Memoir of a length suitable for insertion in the published Transactions of the Association, and that he should send it, together with the original Memoir, by book-post, on or before........................., addressed to the General Secretaries, at the office of the Association. 'For Section.........' If it should be inconvenient to the Author that his paper should be read on any particular days, he is requested to send information thereof to the Secretaries in a separate note. Authors who send in their MSS. three complete weeks before the Meeting, and whose papers are accepted, will be furnished, before the Meeting, with printed copies of their Reports and abstracts. No Report, Paper, or Abstract can be inserted in the Annual Volume unless it is handed either to the Recorder of the Section or to the Assistant Secretary *before the conclusion of the Meeting.*

and printed in the last volume of the Report. He will next proceed to read the Report of the Committee that has held office since the last Annual Meeting. No paper shall be read until it has been formally accepted by the Committee of the Section, and entered on the minutes accordingly. The List of Communications to be read on Thursday shall be then arranged, and the general distribution of business throughout the week shall be provisionally appointed. At the close of the Committee Meeting the Secretaries shall forward to the Printer a List of the Papers appointed to be read. The Printer is charged with publishing the same before 8 A.M. on Thursday in the Journal.

On the second day of the Annual Meeting, and the following days, the Secretaries are to prepare a copy of the Journal for the following day by (i) removing from the list of papers those which have been read on that day ; (ii) making any needful additions to or corrections in the list of those appointed to be read on following days ; (iii) revising the list of the Sectional Committee, and making any other necessary corrections, and to send this copy of the Journal as early in the day as possible to the Printer, who is charged with printing the same before 8 A.M. next morning in the Journal. It is necessary that one of the Secretaries of each Section (generally the Recorder) should call at the Printing Office and revise the proof each evening.

Minutes of the proceedings at each Meeting of the Committee are to be entered in the Minute-Book, and these Minutes should be confirmed at the next meeting of the Committee.

Lists of the Reports and Memoirs read in the Sections are to be entered in the Minute-Book daily, which, with all Memoirs and Copies or Abstracts of Memoirs furnished by Authors, are to be forwarded, at the close of the Sectional Meetings, to the Assistant Secretary of the Association.

The Vice-Presidents and Secretaries of Sections become *ex officio* temporary Members of the General Committee, and will receive, on application to the Treasurer in the Reception Room, tickets entitling them to attend its Meetings.

The Committees will take into consideration any suggestions which may be offered by their Members for the advancement of Science. They are specially requested to review the recommendations adopted at preceding Annual Meetings, as published in the volumes of the Association, and the communications made to the Sections at this Meeting, for the purposes of selecting definite points of research to which individual or combined exertion may be usefully directed, and branches of knowledge on the state and progress of which Reports are wanted ; to name individuals or Committees for the execution of such Reports or researches ; and to state whether, and to what degree, these objects may be usefully advanced by the appropriation of the funds of the Association, by application to Government, Philosophical Institutions, or Local Authorities.

In case of appointment of Committees for special objects of Science it is expedient that all Members of the Committee should be named, and one of them appointed to act as Chairman, who shall have notified personally or in writing his willingness to accept the office, the Chairman to have the responsibility of receiving and disbursing the grant (if any has been made) and securing the presentation of the report in due time ; and, further, it is expedient that one of the members should be appointed to act as Secretary, for ensuring attention to business.

It is desirable that the number of Members appointed to serve on

a Committee should be as small as is consistent with its efficient working.

A tabular list of the Committees appointed on the recommendation of each Section shall be sent each year to the Recorders of the several Sections, to enable them to fill in the statement whether or no the several Committees appointed on the recommendation of their respective Sections have presented their reports.

On the proposal to recommend the appointment of a Committee for a special object of science having been adopted by the Sectional Committee, the number of Members of such Committee shall be then fixed, but the Members to serve on such Committee shall be nominated and selected by the Sectional Committee at a subsequent meeting.

Committees have power to add to their number persons, being Members of the Association, whose assistance they may require.

The recommendations adopted by the Committees of Sections are to be registered on the Forms furnished to their Secretaries, and one Copy of each is to be forwarded, without delay, to the Assistant Secretary of the Association for presentation to the Committee of Recommendations. *Unless this be done, the Recommendations cannot receive the sanction of the Association.*

N.B.—Recommendations which may originate in any one of the Sections must first be sanctioned by the Committee of that Section before they can be referred to the Committee of Recommendations or confirmed by the General Committee.

Notices regarding Grants of Money.[1]

1. No Committee shall raise money in the name or under the auspices of the British Association without special permission from the General Committee to do so; and no money so raised shall be expended except in accordance with the Rules of the Association.
2. In grants of money to Committees the Association does not contemplate the payment of personal expenses to the Members.
3. Committees to which grants of money are entrusted by the Association for the prosecution of particular Researches in Science are appointed for one year only. If the work of a Committee cannot be completed in the year, and if the Sectional Committee desire the work to be continued, application for the reappointment of the Committee for another year must be made at the next meeting of the Association.
4. Each Committee is required to present a Report, whether final or interim, at the next meeting of the Association after their appointment or reappointment. Interim Reports must be submitted in writing, though not necessarily for publication.
5. In each Committee the Chairman is the only person entitled to call on the Treasurer, Professor John Perry, F.R.S., for such portion of the sums granted as may from time to time be required.
6. Grants of money sanctioned at a meeting of the Association expire on June 30 following. The Treasurer is not authorised after that date to allow any claims on account of such grants.

[1] Revised by the General Committee at Ipswich, 1895.

7. The Chairman of a Committee must, before the meeting of the Association next following after the appointment or reappointment of the Committee, forward to the Treasurer a statement of the sums which have been received and expended, with vouchers. The Chairman must also return the balance of the grant, if any, which has been received and not spent; or, if further expenditure is contemplated, he must apply for leave to retain the balance.
8. When application is made for a Committee to be reappointed, and to retain the balance of a former grant which is in the hands of the Chairman, and also to receive a further grant, the amount of such further grant is to be estimated as being additional to, and not inclusive of, the balance proposed to be retained.
9. The Committees of the Sections shall ascertain whether a Report has been made by every Committee appointed at the previous Meeting to whom a sum of money has been granted, and shall report to the Committee of Recommendations in every case where no such report has been received.
10. Members and Committees who may be entrusted with sums of money for collecting specimens of any description are requested to reserve the specimens so obtained to be dealt with by authority of the Council.
11. Committees are requested to furnish a list of any apparatus which may have been purchased out of a grant made by the Association, and to state whether the apparatus will be useful for continuing the research in question, or for other scientific purposes.
12. All Instruments, Papers, Drawings, and other property of the Association are to be deposited at the Office of the Association when not employed in scientific inquiries for the Association.

Business of the Sections.

The Meeting Room of each Section is opened for conversation shortly before the meeting commences. *The Section Rooms and approaches thereto can be used for no notices, exhibitions, or other purposes than those of the Association.*

At the time appointed the Chair will be taken,[1] and the reading of communications, in the order previously made public, commenced.

Sections may, by the desire of the Committees, divide themselves into Departments, as often as the number and nature of the communications delivered in may render such divisions desirable.

A Report presented to the Association, and read to the Section which originally called for it, may be read in another Section, at the request of the Officers of that Section, with the consent of the Author.

Duties of the Doorkeepers.

1. To remain constantly at the Doors of the Rooms to which they are appointed during the whole time for which they are engaged.

[1] The Sectional Committee is empowered to arrange the hours of meeting of the Section and of the Sectional Committee, except for Saturday.

2. To require of every person desirous of entering the Rooms the exhibition of a Member's, Associate's, or Lady's Ticket, or Reporter's Ticket, signed by the Treasurer, or a Special Ticket signed by the Assistant Secretary.
3. Persons unprovided with any of these Tickets can only be admitted to any particular Room by order of the Secretary in that Room.

No person is exempt from these Rules, except those Officers of the Association whose names are printed in the Official Programme, p. 1.

Duties of the Messengers.

To remain constantly at the Rooms to which they are appointed during the whole time for which they are engaged, except when employed on messages by one of the Officers directing these Rooms.

Committee of Recommendations.

The General Committee shall appoint at each Meeting a Committee, which shall receive and consider the Recommendations of the Sectional Committees, and report to the General Committee the measures which they would advise to be adopted for the advancement of Science.

The *ex officio* members of the Committee of Recommendations are the President and Vice-Presidents of the Meeting, the General Secretaries, the General Treasurer, the Trustees, and the Presidents of the Association in former years.

All Recommendations of Grants of Money, Requests for Special Researches, and Reports on Scientific Subjects shall be submitted to the Committee of Recommendations, and shall not be taken into consideration by the General Committee unless previously recommended by the Committee of Recommendations.

All proposals for establishing new Sections, or altering the titles of Sections, or for any other change in the constitutional forms and fundamental rules of the Association, shall be referred to the Committee of Recommendations for a report.[1]

If the President of a Section is unable to attend a meeting of the Committee of Recommendations, the Sectional Committee shall be authorised to appoint a Vice-President, or, failing a Vice-President, some other member of the Committee, to attend in his place, due notice of the appointment being sent to the Assistant Secretary.[2]

Corresponding Societies.[3]

1. (i) Any Society which undertakes local scientific investigation and publishes the results may become a Society *affiliated* to the British Association.

(ii) The Delegates of such Societies, who must be or become members of the British Association, shall be *ex officio* members of the General Committee.

[1] Passed by the General Committee at Birmingham, 1865.
[2] Passed by the General Committee at Leeds, 1890.
[3] Passed by the General Committee, 1884; revised 1903, 1905.

(iii) Any Society formed for the purpose of encouraging the study of science, which has existed for three years and numbers not fewer than fifty members, may become a Society *associated* with the British Association.

(iv) Each associated Society shall have the right to appoint a Delegate to attend the Annual Conference, and such Delegates shall be members or associates of the British Association, and shall have all the rights of those appointed by the affiliated Societies, except that of membership of the General Committee.

2. Application may be made by any Society to be placed on the List of Corresponding Societies. Applications must be addressed to the Assistant Secretary on or before the 1st of June preceding the Annual Meeting at which it is intended they should be considered, and must be accompanied by specimens of the publications of the results of the local scientific investigations recently undertaken by the Society.

3. A Corresponding Societies Committee shall be annually nominated by the Council and appointed by the General Committee for the purpose of considering these applications, as well as for that of keeping themselves generally informed of the annual work of the Corresponding Societies, and of superintending the preparation of a list of the papers published by them. This Committee shall make an annual report to the General Committee, and shall suggest such additions or changes in the List of Corresponding Societies as they may think desirable.

4. Every Corresponding Society shall return each year, on or before the 1st of June, to the Assistant Secretary of the Association, a schedule, properly filled up, which will be issued by him, and which will contain a request for such particulars with regard to the Society as may be required for the information of the Corresponding Societies Committee.

5. There shall be inserted in the Annual Report of the Association a list, in an abbreviated form, of the papers published by the Corresponding Societies during the past twelve months which contain the results of the local scientific work conducted by them; those papers only being included which refer to subjects coming under the cognisance of one or other of the various Sections of the Association.

Conference of Delegates of Corresponding Societies.

6. The Conference of Delegates of Corresponding Societies is empowered to send recommendations to the Committee of Recommendations for their consideration, and for report to the General Committee.

7. The Delegates of the various Corresponding Societies shall constitute a Conference, of which the Chairman, Vice-Chairmen, and Secretaries shall be annually nominated by the Council, and appointed by the General Committee, and of which the members of the Corresponding Societies Committee shall be *ex officio* members.

8. The Conference of Delegates shall be summoned by the Secretaries to hold one or more meetings during each Annual Meeting of the Association, and shall be empowered to invite any Member or Associate to take part in the meetings.

9. The Committee of each Section shall be instructed to transmit to the Secretaries of the Conference of Delegates copies of any recommendations forwarded by the Presidents of Sections to the Committee of Recommendations bearing upon matters in which the co-operation of Corresponding Societies is desired; and the Secretaries of the Conference of Delegates shall invite the authors of these recommendations to attend the meetings of the Conference and give verbal explanations of their objects and of the precise way in which they would desire to have them carried into effect.

10. It will be the duty of the Delegates to make themselves familiar with the purport of the several recommendations brought before the Conference, in order that they and others who take part in the meetings may be able to bring those recommendations clearly and favourably before their respective Societies. The Conference may also discuss propositions bearing on the promotion of more systematic observation and plans of operation, and of greater uniformity in the mode of publishing results.

Local Committees.

Local Committees shall be formed by the Officers of the Association to assist in making arrangements for the Meetings.

Local Committees shall have the power of adding to their numbers those Members of the Association whose assistance they may desire.

Officers.

A President, two or more Vice-Presidents, one or more Secretaries, and a Treasurer shall be annually appointed by the General Committee.

The Council shall appoint and have power to dismiss such paid officers as they may consider necessary to carry on the work of the Association, on such terms as they may from time to time determine.[1]

Council.

In the intervals of the Meetings, the affairs of the Association shall be managed by a Council appointed by the General Committee. The Council may also assemble for the despatch of business during the week of the Meeting.

(1) The Council shall consist of[2]

1. The Trustees.
2. The past Presidents.
3. The President and Vice-Presidents for the time being.
4. The President and Vice-Presidents elect.
5. The past and present General Treasurers and General Secretaries and past Assistant General Secretaries.
6. The Local Treasurer and Secretaries for the ensuing Meeting
7. Ordinary Members.

[1] Passed by the General Committee at Cambridge, 1904.

[2] Passed by the General Committee at Belfast, 1874; amended at Cambridge, 1904.

(2) The Ordinary Members shall be elected annually from the General Committee.

(3) There shall be not more than twenty-five Ordinary Members, of whom not more than twenty shall have served on the Council, as Ordinary Members, in the previous year.

(4) In order to carry out the foregoing rule, the following Ordinary Members of the outgoing Council shall at each annual election be ineligible for nomination:—1st, those who have served on the Council for the greatest number of consecutive years; and, 2nd, those who, being resident in or near London, have attended the fewest number of Meetings during the year —observing (as nearly as possible) the proportion of three by seniority to two by least attendance.

(5) The Council shall submit to the General Committee in their Annual Report the names of twenty-three Members of the General Committee whom they recommend for election as Members of Council.

(i) A nomination for either of the two vacant seats on the Council may be made in writing by any two or more members of the General Committee, and must be sent to the Assistant Secretary so as to be received by him at least twenty-four hours before the Meeting of the General Committee at which the election takes place.

(ii) The nominations shall be read to the Meeting by the Chairman; and if more than two persons be nominated, the election shall be by ballot or show of hands, and the two having the highest numbers of votes shall be declared elected.

(iii) In case no nomination, or only one nomination, shall be received, as provided for by By-law, two seats on the Council (or one seat, as the case may be) shall remain vacant until the next ensuing Meeting of the Council, when the seats (or seat, as the case may be) shall be filled by co-optation of the other members of the Council.[1]

(6) The Election shall take place at the same time as that or the Officers of the Association.

Papers and Communications.

The Author of any paper or communication shall be at liberty to reserve his right of property therein.

Accounts.

The Accounts of the Association shall be audited annually, by Auditors appointed by the General Committee.

[1] Passed by the General Committee at Cambridge, 1904; revised in South Africa, 1905.

Table showing the Places and Times of Meeting of the British Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Commencement.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The EARL FITZWILLIAM, D.C.L., F.R.S., F.G.S., &c. YORK, September 27, 1831.	Rev. W. Vernon Harcourt, M.A., F.R.S., F.G.S.	William Gray, jun., Esq., F.G.S. Professor Phillips, M.A., F.R.S., F.G.S.
The REV. W. BUCKLAND, D.D., F.R.S., F.G.S., &c. OXFORD, June 19, 1832.	Sir David Brewster, F.R.S., F.R.S.E., &c. Rev. W. Whewell, F.R.S., Pres. Geol. Soc.	Professor Daubeny, M.D., F.R.S., &c. Rev. Professor Powell, M.A., F.R.S., &c.
The REV. ADAM SEDGWICK, M.A., V.P.R.S., V.P.G.S. CAMBRIDGE, June 25, 1833.	G. B. Airy, Esq., F.R.S., Astronomer Royal, &c. John Dalton, Esq., D.C.L., F.R.S.	Rev. Professor Henslow, M.A., F.L.S., F.G.S. Rev. W. Whewell, F.R.S.
SIR T. MACDOUGALL BRISBANE, K.C.B., D.C.L., F.R.S., F.R.S.E. EDINBURGH, September 8, 1834.	Sir David Brewster, F.R.S., &c. Rev. T. R. Robinson, D.D.	Professor Forbes, F.R.S., F.R.S.E., &c. Sir John Robinson, Sec. R.S.E.
The REV. PROVOST LLOYD, LL.D. DUBLIN, August 10, 1835.	Viscount Oxmantown, F.R.S., F.R.A.S. Rev. W. Whewell, F.R.S., &c.	Sir W. R. Hamilton, Astron. Royal of Ireland, &c. Rev. Professor Lloyd, F.R.S.
The MARQUIS OF LANSDOWNE, D.C.L., F.R.S. BRISTOL, August 22, 1836.	The Marquis of Northampton, F.R.S. Rev. W. D. Conybeare, F.R.S., F.G.S. J. C. Prichard, Esq., M.D., F.R.S.	Professor Daubeny, M.D., F.R.S., &c. V. F. Hovenden, Esq.
The EARL OF BURLINGTON, F.R.S., F.G.S., Chancellor of the University of London LIVERPOOL, September 11, 1837.	The Bishop of Norwich, P.L.S., F.G.S. John Dalton, Esq., D.C.L., F.R.S. Sir Philip de Grey Egerton, Bart., F.R.S., F.G.S. Rev. W. Whewell, F.R.S.	Professor Traill, M.D. Wm. Wallace Currie, Esq. Joseph N. Walker, Esq., Pres. Royal Institution Liverpool.
The DUKE OF NORTHUMBERLAND, F.R.S., F.G.S., &c. NEWCASTLE-ON-TYNE, August 20, 1838.	The Bishop of Durham, F.R.S., F.S.A. The Rev. W. Vernon Harcourt, F.R.S., &c. Prideaux John Selby, Esq., F.R.S.E.	John Adamson, Esq., F.L.S., &c. Wm. Hutton, Esq., F.G.S. Professor Johnston, M.A., F.R.S.
The REV. W. VERNON HARCOURT, M.A., F.R.S., &c. BIRMINGHAM, August 26, 1839.	The Marquis of Northampton. The Earl of Dartmouth. The Rev. T. R. Robinson, D.D. John Corrie, Esq., F.R.S. The Very Rev. Principal Macfarlane	George Barker, Esq., F.R.S. Peyton Blakiston, Esq., M.D. Joseph Hodgson, Esq., F.R.S. Follett Osler, Esq.

The MARQUIS OF BREADALBANE, F.R.S. GLASGOW, September 17, 1840.	Major-General Lord Greenock, F.R.S.E. Sir David Brewster, F.R.S. Sir T. M. Brisbane, Bart., F.R.S. The Earl of Mount-Edgcumbe	Andrew Liddell, Esq. Rev. J. P. Nicol, LL.D. John Strang, Esq.
The REV. PROFESSOR WHEWELL, F.R.S., &c. PLYMOUTH, July 29, 1841.	The Earl of Morley. Lord Eliot, M.P. Sir C. Lemon, Bart. Sir T. D. Acland, Bart.	W. Snow Harris, Esq., F.R.S. Col. Hamilton Smith, F.L.S. Robert Were Fox, Esq. Richard Taylor, jun., Esq.
The LORD FRANCIS EGERTON, F.G.S. MANCHESTER, June 23, 1842.	John Dalton, Esq., D.C.L., F.R.S. Hon. and Rev. W. Herbert, F.L.S., &c. Rev. A. Sedgwick, M.A., F.R.S. W. C. Henry, Esq., M.D., F.R.S. Sir Benjamin Heywood, Bart.	Peter Clare, Esq., F.R.A.S. W. Fleming, Esq., M.D. James Heywood, Esq., F.R.S.
The EARL OF ROSSE, F.R.S. CORK, August 17, 1843.	The Earl of Listowel. Viscount Adare Sir W. R. Hamilton, Pres. R.I.A. Rev. T. R. Robinson, D.D.	Professor John Stevelly, M.A. Rev. Jos. Carson, F.T.C. Dublin. William Keleher, Esq. Wm. Clear, Esq.
The REV. G. PEACOCK, D.D. (Dean of Ely), F.R.S. YORK, September 26, 1844.	Earl Fitzwilliam, F.R.S. Viscount Morpeth, F.G.S. The Hon. John Stuart Wortley, M.P. Sir David Brewster, K.H., F.R.S. Michael Faraday, Esq., D.C.L., F.R.S. Rev. W. V. Harcourt, F.R.S.	William Hatfeild, Esq., F.G.S. Thomas Meynell, Esq., F.L.S. Rev. W. Scoresby, LL.D., F.R.S. William West, Esq.
SIR JOHN F. W. HERSCHEL, Bart., F.R.S., &c. CAMBRIDGE, June 19, 1845.	The Earl of Hardwicke. The Bishop of Norwich Rev. J. Graham, D.D. Rev. G. Ainslie, D.D. G. B. Airy, Esq., M.A., D.C.L., F.R.S. The Rev. Professor Sedgwick, M.A., F.R.S.	William Hopkins, Esq., M.A., F.R.S. Professor Ansted, M.A., F.R.S.
SIR RODERICK IMPEY MURCHISON, G.C.St.S., F.R.S. SOUTHAMPTON, September 10, 1846.	The Marquis of Winchester. The Earl of Yarborough, D.C.L. Lord Ashburton, D.C.L. Viscount Palmerston, M.P. Right Hon. Charles Shaw Lefevre, M.P. Sir George T. Staunton, Bart., M.P., D.C.L., F.R.S. The Lord Bishop of Oxford, F.R.S. Professor Owen, M.D., F.R.S. The Rev. Professor Powell, F.R.S.	Henry Clark, Esq., M.D. T. H. C. Moody, Esq.
SIR ROBERT HARRY INGLIS, Bart., D.C.L., F.R.S., M.P. for the University of Oxford OXFORD, June 23, 1847.	The Earl of Rosse, F.R.S. The Lord Bishop of Oxford, F.R.S. The Vice-Chancellor of the University Thomas G. Bucknall Estcourt, Esq., D.C.L., M.P. for the University of Oxford. The Very Rev. the Dean of Westminster, D.D., F.R.S. Professor Daubeny, M.D., F.R.S. The Rev. Prof. Powell, M.A., F.R.S.	Rev. Robert Walker, M.A., F.R.S. H. Wentworth Acland, Esq., B.M.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The MARQUIS OF NORTHAMPTON, President of the Royal Society, &c. SWANSEA, August 9, 1848.	The Marquis of Bute, K.T. Viscount Adare, F.R.S. Sir H. T. De la Beche, F.R.S., Pres. G.S. The Very Rev. the Dean of Llandaff, F.R.S. Lewis W. Dillwyn, Esq., F.R.S. W. R. Grove, Esq., F.R.S. J. H. Vivian, Esq., M.P., F.R.S. The Lord Bishop of St. David's	Matthew Moggridge, Esq. D. Nicol, Esq., M.D.
The REV. T. R. ROBINSON, D.D., M.R.I.A., F.R.A.S. BIRMINGHAM, September 12, 1849.	The Earl of Harrowby. The Lord Wrottesley, F.R.S. The Right Hon. Sir Robert Peel, Bart., M.P., D.C.L., F.R.S. Charles Darwin, Esq., M.A., F.R.S., Sec. G.S. Professor Faraday, D.C.L., F.R.S. Sir David Brewster, K.H., LL.D., F.R.S. Rev. Prof. Willis, M.A., F.R.S.	Captain Tindal, R.N. William Wills, Esq. Bell Fletcher, Esq., M.D. James Chance, Esq.
SIR DAVID BREWSTER, K.H., LL.D., F.R.S. L. & E., Principal of the United College of St. Salvator and St. Leonard, St. Andrews. EDINBURGH, July 21, 1850.	The Right Hon. the Lord Provost of Edinburgh The Earl of Cathcart, K.C.B., F.R.S.E. The Earl of Rosebery, K.T., D.C.L., F.R.S. The Right Hon. David Boyle (Lord Justice-General), F.R.S.E. General Sir Thomas M. Brisbane, Bart., D.C.L., F.R.S., Pres. R.S.E. The Very Rev. John Lee, D.D., V.P.R.S.E., Principal of the University of Edinburgh. Professor W. P. Alison, M.D., V.P.R.S.E. Professor J. D. Forbes, F.R.S., Sec. R.S.E.	Rev. Professor Kelland M.A., F.R.S., F.R.S.E. Professor Balfour, M.D., F.R.S.E., F.L.S. James Tod, Esq., F.R.S.E.
GEORGE BIDDELL AIRY, Esq., D.C.L., F.R.S., Astronomer Royal. IPSWICH, July 2, 1851.	The Lord Rendlesham, M.P. The Lord Bishop of Norwich Rev. Professor Sedgwick, M.A., F.R.S. Rev. Professor Henslow, M.A., F.L.S. Sir John P. Boileau, Bart., F.R.S. Sir William F. F. Middleton, Bart. J. C. Cobbold, Esq., M.P. T. B. Western, Esq.	Charles May, Esq., F.R.A.S. Dillwyn Sims, Esq. George Arthur Biddell, Esq. George Ransome, Esq., F.L.S.
COLONEL EDWARD SABINE, Royal Artillery, Treas. & V.P. of the Royal Society. BELFAST, September 1, 1852.	The Earl of Enniskillen, D.C.L., F.R.S. The Earl of Rosse, Pres. R.S., M.R.I.A. Sir Henry T. De la Beche, F.R.S. Rev. Edward Hincks, D.D., M.R.I.A. Rev. P. S. Henry, D.D., Pres. Queen's College, Belfast Rev. T. R. Robinson, D.D., Pres. R.I.A., F.R.A.S. Professor G. G. Stokes, F.R.S. Professor Stevelly, LL.D.	W. J. C. Allen, Esq. William M'Gee, Esq., M.D. Professor W. P. Wilson.
WILLIAM HOPKINS, Esq., M.A., V.P.R.S., F.G.S., Pres. Camb. Phil. Society. HULL, September 7, 1853.	The Earl of Carlisle, F.R.S. Lord Londesborough, F.R.S. Professor Faraday, D.C.L., F.R.S. Rev. Prof. Sedgwick, M.A., F.R.S. Charles Frost, Esq., F.S.A., Pres. of the Hull Lit. and Phil. Society William Spence, Esq., F.R.S. Lieut.-Col. Sykes, F.R.S. Professor Wheatstone, F.R.S.	Henry Cooper, Esq., M.D., V.P. Hull Lit. & Phil. Society. Bethel Jacobs, Esq., Pres. Hull Mechanics' Inst.
The EARL OF HARROWBY, F.R.S. LIVERPOOL, September 20, 1854.	The Lord Wrottesley, M.A., F.R.S., F.R.A.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Professor Owen, M.D., LL.D., F.R.S., F.L.S., F.G.S. Rev. Professor Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., Master of Trinity College, Cambridge William Lassell, Esq., F.R.S., F.R.S.E., F.R.A.S. Joseph Brooks Yates, Esq., F.S.A., F.R.G.S.	Joseph Dickinson, Esq., M.D., F.R.S. Thomas Inman, Esq., M.D.

The DUKE OF ARGYLL, F.R.S., F.G.S. GLASGOW, September 12, 1855.	The Very Rev. Principal Macfarlane, D.D. Sir William Jardine, Bart., F.R.S.E. Sir Charles Lyell, M.A., LL.D., F.R.S. James Smith, Esq., F.R.S., F.R.S.E. Walter Crum, Esq., F.R.S. Thomas Graham, Esq., M.A., F.R.S., Master of the Royal Mint. Professor William Thomson, M.A., F.R.S.	John Strang, Esq., LL.D. Professor Thomas Anderson, M.D. William Gourlie, Esq.
CHARLES G. B. DAUBENY, Esq., M.D., LL.D., F.R.S., Professor of Botany in the University of Oxford CHELTENHAM, August 6, 1856.	The Earl of Ducie, F.R.S., F.G.S. The Lord Bishop of Gloucester and Bristol Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. Thomas Barwick Lloyd Baker, Esq. The Rev. Francis Close, M.A.	Capt. Robinson, R.A. Richard Beamish, Esq., F.R.S. John West Hugell, Esq.
The REV. HUMPHREY LLOYD, D.D., D.C.L., F.R.S., F.R.S.E., V.P.R.I.A. DUBLIN, August 26, 1857.	The Right Hon. the Lord Mayor of Dublin The Provost of Trinity College, Dublin The Marquis of Kildare. Lord Talbot de Malahide The Lord Chancellor of Ireland The Lord Chief Baron, Dublin Sir William R. Hamilton, LL.D., F.R.A.S., Astronomer Royal of Ireland Lieut.-Colonel Larcom, R.E., LL.D., F.R.S. Richard Griffith, Esq., LL.D., M.R.I.A., F.R.S.E., F.G.S.	Lundy E. Foote, Esq. Rev. Professor Jellett, F.T.C.D. W. Neilson Hancock, Esq., LL.D.
RICHARD OWEN, Esq., M.D., D.C.L., V.P.R.S., F.L.S., F.G.S., Superintendent of the Natural History Departments of the British Museum. LEEDS, September 22 1858.	The Lord Monteagle, F.R.S. The Lord Viscount Goderich, M.P., F.R.G.S. The Right Hon. M. T. Baines, M.A., M.P. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. The Rev. W. Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., F.R.A.S., Master of Trinity College, Cambridge James Garth Marshall, Esq., M.A., F.G.S. R. Monckton Milnes, Esq., D.C.L., M.P., F.R.G.S.	Rev. Thomas Hincks, B.A. W. Sykes Ward, Esq., F.C.S. Thomas Wilson, Esq., M.A.
HIS ROYAL HIGHNESS THE PRINCE CONSORT ABERDEEN, September 14, 1859.	The Duke of Richmond, K.G., F.R.S. The Earl of Aberdeen, LL.D., K.G., K.T., F.R.S. The Lord Provost of the City of Aberdeen Sir John F. W. Herschel, Bart., M.A., D.C.L., F.R.S. Sir David Brewster, K.H., D.C.L., F.R.S. Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. The Rev. W. V. Harcourt, M.A., F.R.S. The Rev. T. R. Robinson, D.D., F.R.S. A. Thomson, Esq., LL.D., F.R.S., Convener of the County of Aberdeen	Professor J. Nicol, F.R.S.E., F.G.S. Professor Fuller, M.A. John F. White, Esq.
The LORD WROTTESLEY, M.A., V.P.R.S., F.R.A.S. OXFORD, June 27, 1860.	The Earl of Derby, K.G., P.C., D.C.L., Chancellor of the Univ. of Oxford The Rev. F. Jeune, D.C.L., Vice-Chancellor of the University of Oxford The Duke of Marlborough, D.C.L., F.G.S., Lord Lieutenant of Oxfordshire The Earl of Rosse, K.P., M.A., F.R.S., F.R.A.S. The Lord Bishop of Oxford, D.D., F.R.S. The Very Rev. H. G. Liddell, D.D., Dean of Christ Church, Oxford Professor Daubeny, M.D., LL.D., F.R.S., F.L.S., F.G.S. Professor Acland, M.D., F.R.S. Professor Donkin, M.A., F.R.S., F.R.A.S.	George Rolleston, Esq., M.D., F.L.S. H. J. S. Smith, Esq., M.A., F.C.S. George Griffith, Esq., M.A., F.C.S.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
WILLIAM FAIRBAIRN, Esq., LL.D., C.E., F.R.S. MANCHESTER, September 4, 1861.	The Earl of Ellesmere, F.R.G.S. The Lord Stanley, M.P., D.C.L., F.R.G.S. The Lord Bishop of Manchester, D.D., F.R.S., F.G.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Sir Benjamin Heywood, Bart., F.R.S. Thomas Bazley, Esq., M.P. James Aspinall Turner, Esq., M.P. James Prescott Joule, Esq., LL.D., F.R.S., Pres. Lit. & Phil. Soc. Manchester Professor E. Hodgkinson, F.R.S., M.R.I.A., M.Inst.C.E. Joseph Whitworth, Esq., F.R.S., M.Inst.C.E.	R. D. Darbishire, Esq., B.A., F.G.S. Alfred Neild, Esq. Arthur Ransome, Esq., M.A. Professor H. E. Roscoe, B.A.
The REV. R. WILLIS, M.A., F.R.S., Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge CAMBRIDGE, October 1, 1862.	The Rev. the Vice-Chancellor of the University of Cambridge The Very Rev. Harvey Goodwin, D.D., Dean of Ely The Rev. W. Whewell, D.D., F.R.S., Master of Trinity College, Cambridge The Rev. Professor Sedgwick, M.A., D.C.L., F.R.S. The Rev. J. Challis, M.A., F.R.S. G. B. Airy, Esq., M.A., D.C.L., F.R.S., Astronomer Royal Professor G. G. Stokes, M.A., D.C.L., Sec. R.S. Professor J. C. Adams, M.A., D.C.L., F.R.S., Pres. C.P.S.	Professor C. C. Babington, M.A., F.R.S., F.L.S. Professor G. D. Liveing, M.A. The Rev. N. M. Ferrers, M.A.
SIR W. ARMSTRONG, C.B., LL.D., F.R.S. NEWCASTLE-ON-TYNE, August 26, 1863.	Sir Walter C. Trevelyan, Bart., M.A. Sir Charles Lyell, LL.D., D.C.L., F.R.S., F.G.S. Hugh Taylor, Esq., Chairman of the Coal Trade Isaac Lowthian Bell, Esq., Mayor of Newcastle Nicholas Wood, Esq., President of the Northern Institute of Mining Engineers Rev. Temple Chevallier, B.D., F.R.A.S. William Fairbairn, Esq., LL.D., F.R.S.	A. Noble, Esq. Augustus H. Hunt, Esq. R. C. Clapham, Esq.
SIR CHARLES LYELL, Bart., M.A., D.C.L., F.R.S. BATH, September 14, 1864.	The Right Hon. the Earl of Cork and Orrery, Lord-Lieutenant of Somersetshire The Most Noble the Marquis of Bath The Right Hon. Earl Nelson The Right Hon. Lord Portman The Very Rev. the Dean of Hereford The Venerable the Archdeacon of Bath W. Tite, Esq., M.P., F.R.S., F.G.S., F.S.A. A. E. Way, Esq., M.P. Francis H. Dickinson, Esq. W. Sanders, Esq., F.R.S., F.G.S.	C. Moore, Esq., F.G.S. C. E. Davis, Esq. The Rev. H. H. Winwood, M.A.
JOHN PHILLIPS, Esq., M.A., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford BIRMINGHAM, September 6, 1865.	The Right Hon. the Earl of Lichfield, Lord-Lieutenant of Staffordshire The Right Hon. the Earl of Dudley The Right Hon. Lord Leigh, Lord-Lieutenant of Warwickshire The Right Hon. Lord Lyttelton, Lord-Lieutenant of Worcestershire The Right Hon. Lord Wrottesley, M.A., D.C.L., F.R.S., F.R.A.S. The Right Rev. the Lord Bishop of Worcester The Right Hon. C. B. Adderley, M.P. William Scholefield, Esq., M.P. F. Osler, Esq., F.R.S. J. T. Chance, Esq. The Rev. Charles Evans, M.A.	William Mathews, jun., Esq., M.A., F.G.S. John Henry Chamberlain, Esq. The Rev. G. D. Boyle, M.A.

WILLIAM R. GROVE, Esq., Q.C., M.A., F.R.S. NOTTINGHAM, August 22, 1866.	His Grace the Duke of Devonshire, Lord-Lieutenant of Derbyshire His Grace the Duke of Rutland, Lord-Lieutenant of Leicestershire The Right Hon. Lord Belper, Lord-Lieutenant of Nottinghamshire The Right Hon. J. E. Denison, M.P. J. C. Webb, Esq., High-Sheriff of Nottinghamshire Thomas Graham, Esq., F.R.S., Master of the Mint Joseph Hooker, Esq., M.D., F.R.S., F.L.S. John Russell Hind, Esq., F.R.S., F.R.A.S. T. Close, Esq.	Dr. Robertson. Edward J. Lowe, Esq., F.R.A.S., F.L.S. The Rev. J. F. M'Callan, M.A.
HIS GRACE THE DUKE OF BUCCLEUCH, K.G., D.C.L., F.R.S. DUNDEE, September 4, 1867.	The Right Hon. the Earl of Airlie, K.T. The Right Hon. the Lord Kinnaird, K.T. Sir John Ogilvy, Bart., M.P. Sir Roderick I. Murchison, Bart., K.C.B., LL.D., F.R.S., F.G.S., &c. Sir David Baxter, Bart. Sir David Brewster, D.C.L., F.R.S., Principal of the University of Edinburgh James D. Forbes, Esq., LL.D., F.R.S., Principal of the United College of St. Salvator and St. Leonard, University of St. Andrews	J. Henderson, jun., Esq. John Austin Lake Gloag, Esq. Patrick Anderson, Esq.
JOSEPH DALTON HOOKER, Esq., M.D., D.C.L., F.R.S., F.L.S. NORWICH, August 19, 1868.	The Right Hon. the Earl of Leicester, Lord-Lieutenant of Norfolk Sir John Peter Boileau, Bart., F.R.S. The Rev. Adam Sedgwick, M.A., LL.D., F.R.S., F.G.S., &c., Woodwardian Professor of Geology in the University of Cambridge Sir John Lubbock, Bart., F.R.S., F.L.S., F.G.S. John Couch Adams, Esq., M.A., D.C.L., F.R.S., F.R.A.S., Lowndean Professor of Astronomy and Geometry in the University of Cambridge Thomas Brightwell, Esq.	Dr. Donald Dalrymple. Rev. Joseph Crompton, M.A. Rev. Canon Hinds Howell.
PROFESSOR GEORGE G. STOKES, D.C.L., F.R.S. EXETER, August 18, 1869.	The Right Hon. the Earl of Devon The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P., &c. Sir John Bowring, LL.D., F.R.S. William B. Carpenter, Esq., M.D., F.R.S., F.L.S. Robert Were Fox, Esq., F.R.S. W. H. Fox Talbot, Esq., M.A., LL.D., F.R.S., F.L.S.	Henry S. Ellis, Esq., F.R.A.S. John C. Bowring, Esq. The Rev. R. Kirwan.
PROFESSOR T. H. HUXLEY, LL.D., F.R.S., F.G.S. LIVERPOOL, September 14, 1870.	The Right Hon. the Earl of Derby, LL.D., F.R.S. Sir Philip de Malpas Grey Egerton, Bart., M.P. The Right Hon. W. E. Gladstone, D.C.L., M.P. S. R. Graves, Esq., M.P. Sir Joseph Whitworth, Bart., LL.D., D.C.L., F.R.S. James P. Joule, Esq., LL.D., D.C.L., F.R.S. Joseph Mayer, Esq., F.S.A., F.R.G.S.	Rev. W. Banister. Reginald Harrison, Esq. Rev. Henry H. Higgins, M.A. Rev. Dr. A. Hume, F.S.A.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
PROFESSOR SIR WILLIAM THOMSON, M.A., LL.D., F.R.S., F.R.S.E. EDINBURGH, August 2, 1871.	His Grace the Duke of Buccleuch, K.G., D.C.L., F.R.S. The Right Hon. the Lord Provost of Edinburgh The Right Hon. John Inglis, LL.D., Lord Justice-General of Scotland Sir Alexander Grant, Bart., M.A., Principal of the University of Edinburgh Sir Roderick I. Murchison, Bart., K.C.B., G.C.St.S., D.C.L., F.R.S. Sir Charles Lyell, Bart., D.C.L., F.R.S., F.G.S. Dr. Lyon Playfair, C.B., M.P., F.R.S. Professor Christison, M.D., D.C.L., Pres. R.S.E. Professor Balfour, F.R.S., F.R.S.E.	Professor A. Crum Brown, M.D., F.R.S.E. J. D. Marwick, Esq., F.R.S.E.
W. B. CARPENTER, Esq., M.D., LL.D., F.R.S., F.L.S. BRIGHTON, August 14, 1872.	The Right Hon. the Earl of Chichester, Lord-Lieutenant of the County of Sussex. His Grace the Duke of Norfolk His Grace the Duke of Richmond, K.G., P.C., D.C.L. His Grace the Duke of Devonshire, K.G., D.C.L., F.G.S. Sir John Lubbock, Bart., M.P., F.R.S., F.L.S., F.G.S. Dr. Sharpey, LL.D., Sec. R.S., F.L.S. Joseph Prestwich, Esq., F.R.S., Pres. G.S.	Charles Carpenter, Esq. The Rev. Dr. Griffith. Henry Willett, Esq.
PROFESSOR ALEXANDER W. WILLIAMSON, Ph.D., F.R.S., F.C.S. BRADFORD, September 17, 1873.	The Right Hon. the Earl of Rosse, F.R.S., F.R.A.S. The Right Hon. Lord Houghton, D.C.L., F.R.S. The Right Hon. W. E. Forster, M.P. The Mayor of Bradford. Sir John Hawkshaw, F.R.S., F.G.S. J. P. Gassiot, Esq., D.C.L., F.R.S. Professor Phillips, D.C.L., F.R.S.	The Rev. J. R. Campbell, D.D. Richard Goddard, Esq. Peile Thompson, Esq.
PROFESSOR J. TYNDALL, D.C.L., LL.D., F.R.S. BELFAST, August 19, 1874.	The Right Hon. the Earl of Enniskillen, D.C.L., F.R.S. The Right Hon. the Earl of Rosse, F.R.S. Sir Richard Wallace, Bart., M.P. The Rev. Dr. Henry. Dr. Andrews, F.R.S. The Rev. Dr. Robinson, F.R.S. Professor Stokes, D.C.L., F.R.S.	W. Quartus Ewart, Esq. Professor G. Fuller, C.E. T. Sinclair, Esq.
SIR JOHN HAWKSHAW, M.Inst.C.E., F.R.S., F.G.S. BRISTOL, August 25, 1875.	The Right Hon. the Earl of Ducie, F.R.S., F.G.S. The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P., F.R.S. The Mayor of Bristol Major-General Sir Henry C. Rawlinson, K.C.B., LL.D., F.R.S., F.R.G.S. Dr. W. B. Carpenter, LL.D., F.R.S., F.L.S., F.G.S. W. Sanders, Esq., F.R.S., F.G.S.	W. Lant Carpenter, Esq., B.A., B.Sc., F.C.S. John H. Clarke, Esq.
PROFESSOR THOMAS ANDREWS, M.D., LL.D., F.R.S., Hon. F.R.S.E. GLASGOW, September 6, 1876.	His Grace the Duke of Argyll, K.T., LL.D., F.R.S., F.R.S.E., F.G.S. The Hon. the Lord Provost of Glasgow Sir William Stirling Maxwell, Bart., M.A., M.P. Professor Sir William Thomson, M.A., LL.D., D.C.L., F.R.S., F.R.S.E. Professor Allen Thomson, M.D., LL.D., F.R.S., F.R.S.E. Professor A. C. Ramsay, LL.D., F.R.S., F.G.S. James Young, Esq., F.R.S., F.C.S.	Dr. W. G. Blackie, F.R.G.S. James Grahame, Esq. J. D. Marwick, Esq.

PROFESSOR ALLEN THOMSON, M.D., LL.D., F.R.S., F.R.S.E. PLYMOUTH, August 15, 1877.	The Right Hon. the Earl of Mount-Edgcumbe The Right Hon. Lord Blachford, K.C.M.G. William Spottiswoode, Esq., M.A., LL.D., F.R.S., F.R.A.S., F.R.G.S. William Froude, Esq., M.A., C.E., F.R.S. Charles Spence Bate, Esq., F.R.S., F.L.S.	William Adams, Esq. William Square, Esq. Hamilton Whiteford, Esq.
WILLIAM SPOTTISWOODE, Esq., M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S. DUBLIN, August 14, 1878.	The Right Hon. the Lord Mayor of Dublin The Provost of Trinity College, Dublin His Grace the Duke of Abercorn, K.G. The Right Hon. the Earl of Enniskillen, D.C.L., F.R.S., F.G.S. The Right Hon. the Earl of Rosse, B.A., D.C.L., F.R.S., F.R.A.S., M.R.I.A. The Right Hon. Lord O'Hagan, M.R.I.A. Professor G. G. Stokes, M.A., D.C.L., LL.D., Sec. R.S.	Professor R. S. Ball, M.A., F.R.S. James Goff, Esq. John Norwood, Esq., LL.D. Professor G. Sigerson, M.D.
PROFESSOR G. J. ALLMAN, M.D., LL.D., F.R.S., F.R.S.E., M.R.I.A., Pres. L.S. SHEFFIELD, August 20, 1879.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.R.G.S. The Right Hon. the Earl Fitzwilliam, K.G., F.R.G.S. The Right Hon. the Earl of Wharncliffe, F.R.G.S. W. H. Brittain, Esq. (Master Cutler) Professor T. H. Huxley, Ph.D., LL.D., Sec. R.S., F.L.S., F.G.S. Professor W. Odling, M.B., F.R.S., F.C.S.	H. Clifton Sorby, Esq., LL.D., F.R.S., F.G.S. J. F. Moss, Esq.
ANDREW CROMBIE RAMSAY, Esq., LL.D., F.R.S., V.P.G.S., Director-General of the Geological Survey of the United Kingdom, and of the Museum of Practical Geology SWANSEA, August 25, 1880.	The Right Hon. the Earl of Jersey The Mayor of Swansea The Hon. Sir W. R. Grove, M.A., D.C.L., F.R.S. H. Hussey Vivian, Esq., M.P., F.G.S. L. Ll. Dillwyn, Esq., M.P., F.L.S., F.G.S. J. Gwyn Jeffreys, Esq., LL.D., F.R.S., F.L.S., Treas. G.S., F.R.G.S.	W. Morgan Esq., Ph.D., F.C.S. James Strick, Esq.
SIR JOHN LUBBOCK, Bart., M.P., D.C.L., LL.D., F.R.S., Pres. L.S., F.G.S. YORK, August 31, 1881.	His Grace the Archbishop of York, D.D., F.R.S. The Right Hon. the Lord Mayor of York The Right Hon. Lord Houghton, D.C.L., F.R.S., F.R.G.S. The Venerable Archdeacon Creyke, M.A. The Hon. Sir W. R. Grove, M.A., D.C.L., F.R.S. Professor G. G. Stokes, M.A., D.C.L., LL.D., Sec. R.S. Sir John Hawkshaw, M.Inst.C.E., F.R.S., F.G.S., F.R.G.S. Allen Thomson, Esq., M.D., LL.D., F.R.S. L. & E. Professor Allman, M.D., LL.D., F.R.S. L. & E., F.L.S.	Rev. Thomas Adams, M.A. Tempest Anderson, Esq., M.D., B.Sc.
C. W. SIEMENS, Esq., D.C.L., LL.D., F.R.S., F.C.S., M.Inst.C.E. SOUTHAMPTON, August 23, 1882.	The Right Hon. the Lord Mount-Temple Captain Sir F. J. Evans, K.C.B., F.R.S., F.R.A.S., F.R.G.S., Hydrographer to the Admiralty F. A. Abel, Esq., C.B., F.R.S., V.P.C.S., Director of the Chemical Establishment of the War Department Professor De Chaumont, M.D., F.R.S. Major-General A. C. Cooke, R.E., C.B., F.R.G.S., Director-General of the Ordnance Survey. Wyndham S. Portal, Esq. Professor Prestwich, M.A., F.R.S., F.G.S., F.C.S. Philip Lutley Sclater, Esq., M.A., Ph.D., F.R.S., F.L.S., F.G.S.	C. W. A. Jellicoe, Esq. John E. Le Feuvre, Esq. Morris Miles, Esq.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
ARTHUR CAYLEY, Esq., M.A., D.C.L., LL.D., F.R.S., V.P.R.A.S., Sadlerian Professor of Pure Mathematics in the University of Cambridge SOUTHPORT, September 19, 1883.	The Right Hon. the Earl of Derby, M.A., LL.D., F.R.S., F.R.G.S. The Right Hon. the Earl of Crawford and Balcarres, LL.D., F.R.S., F.R.A.S. The Right Hon. the Earl of Lathom. Principal J. W. Dawson, C.M.G., M.A., LL.D., F.R.S., F.G.S. J. G. Greenwood, Esq., LL.D., Vice-Chancellor of the Victoria University Professor H. E. Roscoe, Ph.D., LL.D., F.R.S., F.C.S.	J. H. Ellis, Esq. Dr. Vernon. T. W. Willis, Esq.
The RIGHT HON. LORD RAYLEIGH, M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S., Professor of Experimental Physics in the University of Cambridge. MONTREAL, August 27, 1884.	His Excellency the Governor-General of Canada, G.C.M.G., LL.D. The Right Hon. Sir John Alexander Macdonald, K.C.B., D.C.L., LL.D. The Right Hon. Sir Lyon Playfair, K.C.B., M.P., LL.D., F.R.S. L. & E. The Hon. Sir Alexander Tilloch Galt, G.C.M.G. The Hon. Sir Charles Tupper, K.C.M.G. Chief Justice Sir A. A. Dorion, C.M.G. Principal Sir William Dawson, C.M.G., M.A., LL.D., F.R.S., F.G.S. The Hon. Dr. Chauveau. Professor Edward Frankland, M.D., D.C.L., Ph.D., LL.D., F.R.S., F.C.S. W. H. Hingston, Esq., M.D., D.C.L., L.R.C.S.E. Thomas Sterry Hunt, Esq., M.A., D.Sc., LL.D., F.R.S.	S. E. Dawson, Esq. R. A. Ramsay, Esq. S. Rivard, Esq. S. C. Stevenson, Esq. Thos. White, Esq., M.P.
The RIGHT HON. SIR LYON PLAYFAIR, K.C.B., M.P., Ph.D., LL.D., F.R.S., F.R.S.E., F.C.S. ABERDEEN, September 9, 1885.	His Grace the Duke of Richmond and Gordon, K.G., D.C.L., Chancellor of the University of Aberdeen The Right Hon. the Earl of Aberdeen, LL.D., Lord-Lieutenant of Aberdeenshire The Right Hon. the Earl of Crawford and Balcarres, M.A., LL.D., F.R.S., F.R.A.S. James Matthews, Esq., Lord Provost of the City of Aberdeen Professor Sir William Thomson, M.A., LL.D., F.R.S., F.R.S.E., F.R.A.S. Alexander Bain, Esq., M.A., LL.D., Rector of the University of Aberdeen The Very Rev. Principal Pirie, D.D., Vice-Chancellor of the University of Aberdeen Professor W. H. Flower, LL.D., F.R.S., F.L.S., Pres. Z.S., F.G.S., Director of the Natural History Museum, London Professor John Struthers, M.D., LL.D.	J. W. Crombie, Esq., M.A. Angus Fraser, Esq., M.A., M.D., F.C.S. Professor G. Pirie, M.A.
SIR J. WILLIAM DAWSON, C.M.G., M.A., LL.D., F.R.S., F.G.S., Principal and Vice-Chancellor of McGill University, Montreal, Canada BIRMINGHAM, September 1, 1886.	The Right Hon. the Earl of Bradford, Lord-Lieutenant of Shropshire. The Right Hon. Lord Leigh, D.C.L., Lord-Lieutenant of Warwickshire. The Right Hon. Lord Norton, K.C.M.G. The Right Hon. Lord Wrottesley, Lord-Lieutenant of Staffordshire The Right Rev. the Lord Bishop of Worcester, D.D. Thomas Martineau, Esq., Mayor of Birmingham Professor G. G. Stokes, M.A., D.C.L., LL.D., Pres. R.S. Professor W. A. Tilden, D.Sc., F.R.S., F.C.S. Rev. A. R. Vardy, M.A. Rev. H. W. Watson, D.Sc., F.R.S.	J. Barham Carslake, Esq. Rev. H. W. Crosskey, LL.D., F.G.S. Charles J. Hart, Esq.

SIR H. E. ROSCOE, M.P., D.C.L., LL.D., Ph.D., F.R.S., V.P.C.S. MANCHESTER, August 31, 1887.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.G.S., F.R.G.S. The Right Hon. the Earl of Derby, K.G., M.A., LL.D., F.R.S., F.R.G.S. The Right Rev. the Lord Bishop of Manchester, D.D. The Right Rev. the Bishop of Salford The Right Worshipful the Mayor of Manchester The Right Worshipful the Mayor of Salford The Vice-Chancellor of the Victoria University The Principal of the Owens College Sir William Roberts, B.A., M.D., F.R.S. Thomas Ashton, Esq., J.P., D.L. Oliver Heywood, Esq., J.P., D.L. James Prescott Joule, Esq., D.C.L., LL.D., F.R.S., F.R.S.E., F.C.S.	F. J. Faraday, Esq., F.L.S., F.S.S. Charles Hopkinson, Esq., B.Sc. Professor A. Milnes Marshall, M.A., M.D., D.Sc., F.R.S. Professor A. H. Young, M.B., F.R.C.S.
SIR FREDERICK J. BRAMWELL, D.C.L., F.R.S., M.Inst.C.E. BATH, September 5, 1888.	The Right Hon. the Earl of Cork and Orrery, Lord-Lieutenant of Somerset The Most Hon. the Marquess of Bath The Right Hon. and Right Rev. the Lord Bishop of Bath and Wells, D.D. The Right Rev. the Bishop of Clifton, D.D. The Right Worshipful the Mayor of Bath The Right Worshipful the Mayor of Bristol Sir F. A. Abel, C.B., D.C.L., F.R.S., V.P.C.S. The Venerable the Archdeacon of Bath, M.A. The Rev. Leonard Blomefield, M.A., F.L.S., F.G.S. Professor Michael Foster, M.A., M.D., LL.D., Sec. R.S., F.L.S., F.C.S. W. S. Gore-Langton, Esq., J.P., D.L. H. D. Skrine, Esq., J.P., D.L. E. R. Wodehouse, Esq., M.P. Colonel R. P. Laurie, C.B., M.P. Jerom Murch, Esq., J.P., D.L.	W. Pumphrey, Esq. J. L. Stothert, Esq., M.Inst.C.E. B. H. Watts, Esq.
PROFESSOR WILLIAM HENRY FLOWER, C.B., LL.D., F.R.S., F.R.C.S., Pres. Z.S., F.L.S., F.G.S., Director of the Natural History Departments of the British Museum NEWCASTLE-UPON-TYNE, September 11, 1889.	His Grace the Duke of Northumberland, K.G., D.C.L., LL.D., Lord-Lieutenant of Northumberland The Right Hon. the Earl of Durham, Lord-Lieutenant of Durham The Right Hon. the Earl of Ravensworth The Right Rev. the Lord Bishop of Newcastle, D.D. The Right Hon. Lord Armstrong, C.B., D.C.L., LL.D., F.R.S. The Right Hon. John Morley, M.P., LL.D. The Very Rev. the Warden of the University of Durham, D.D. The Right Worshipful the Mayor of Newcastle The Worshipful the Mayor of Gateshead Sir I. Lowthian Bell, Bart., D.C.L., F.R.S., F.C.S., M.Inst.C.E. Sir Charles Mark Palmer, Bart., M.P.	Professor P. Phillips Bedson, D.Sc., F.C.S. Professor J. Herman Merivale, M.A.
SIR FREDERICK AUGUSTUS ABEL, C.B., D.C.L., D.Sc., F.R.S., P.P.C.S., Hon.M.Inst.C.E. LEEDS, September 3, 1890.	His Grace the Duke of Devonshire, K.G., M.A., LLD., F.R.S., F.G.S. The Most Hon. the Marquess of Ripon, K.G., G.C.S.I., C.I.E., F.R.S. The Right Hon. the Earl Fitzwilliam, K.G., F.R.G.S. The Right Rev. the Lord Bishop of Ripon, D.D. The Right Hon. Sir Lyon Playfair, K.C.B., Ph.D., LL.D., M.P., F.R.S. The Right Hon. W. L. Jackson, M.P. Sir James Kitson Bart., M.Inst.C.E. The Mayor of Leeds Sir Andrew Fairbairn, M.A.	J. Rawlinson Ford, Esq. Sydney Lupton, Esq., M.A. Professor L. C. Miall, F.L.S., F.G.S. Professor A. Smithells, B.Sc.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
WILLIAM HUGGINS, Esq., D.C.L., LL.D., Ph.D., F.R.S., F.R.A.S., Hon. F.R.S.E. CARDIFF, August 19, 1891.	The Right Hon. Lord Windsor, Lord-Lieutenant of Glamorganshire The Most Hon. the Marquess of Bute, K.T. The Right Hon. Lord Rayleigh, M.A., D.C.L., LL.D., Sec.R.S., F.R.A.S. The Right Hon. Lord Tredegar The Right Hon. Lord Aberdare, G.C.B., F.R.S., F.R.G.S. Sir J. T. D. Llewelyn, Bart., F.Z.S. Sir Archibald Geikie, LL.D., D.Sc., For.Sec.R.S., F.R.S.E., Pres.G.S. Sir Robert Ball, LL.D., F.R.S., F.R.A.S., Royal Astronomer of Ireland	R. W. Atkinson, Esq., B.Sc., F.C.S., F.I.C., Professor H. W. Lloyd Tanner, M.A., F.R.A.S.
SIR ARCHIBALD GEIKIE, LL.D., D.Sc., For. Sec. R.S., F.R.S.E., F.G.S., Director-General of the Geological Survey of the United Kingdom. EDINBURGH, August 3, 1892.	The Right Hon. the Lord Provost of Edinburgh The Most Hon. the Marquess of Lothian, K.T. The Right Hon. the Earl of Rosebery, LL.D., F.R.S., F.R.S.E. The Right Hon. J. H. A. Macdonald, C.B., LL.D., F.R.S., F.R.S.E. Principal Sir William Muir, K.C.S.I., D.C.L. Professor Sir Douglas Maclagan, M.D., Pres.R.S.E. Professor Sir William Turner, F.R.S., F.R.S.E. Professor P. G. Tait, M.A., F.R.S.E. Professor A. Crum Brown, M.D., F.R.S., F.R.S.E., Pres.C.S.	Professor G. F. Armstrong, M.A., M.Inst.C.E., F.R.S.E., F.G.S. F. Grant Ogilvie, Esq., M.A., B.Sc., F.R.S.E. John Harrison, Esq.
DR. J. S. BURDON SANDERSON, M.A., M.D., LL.D., D.C.L., F.R.S., F.R.S.E., Professor of Physiology in the University of Oxford NOTTINGHAM, September 13, 1893.	His Grace the Duke of St. Albans, Lord-Lieut. of Nottinghamshire His Grace the Duke of Devonshire, K.G., Chancellor of the University of Cambridge His Grace the Duke of Portland. His Grace the Duke of Newcastle The Right Hon. Lord Belper. The Mayor of Nottingham The Right Hon. Sir W. R. Grove, F.R.S. Sir John Turney, J.P. Professor Michael Foster, M.A., Sec.R.S. W. H. Ransom, Esq., M.D., F.R.S.	Professor F. Clowes, D.Sc. Professor W. H. Heaton, M.A. Arthur Williams, Esq.
The MOST HON. THE MARQUIS OF SALISBURY, K.G., D.C.L., F.R.S., Chancellor of the University of Oxford. OXFORD, August 8, 1894.	The Right Hon. the Earl of Jersey, G.C.M.G., Lord-Lieutenant of the County of Oxford The Right Hon. Lord Wantage, K.C.B., V.C., Lord-Lieutenant of Berkshire The Right Hon. the Earl of Rosebery, K.G., D.C.L., F.R.S. The Right Rev. the Lord Bishop of Oxford, D.D. The Right Hon. Lord Rothschild, Lord-Lieutenant of Buckinghamshire The Right Hon. Lord Kelvin, D.C.L., Pres.R.S. The Rev. the Vice-Chancellor of the University of Oxford The Mayor of Oxford Sir W. R. Anson, D.C.L., Warden of All Souls College Sir Bernhard Samuelson, Bart., M.P., F.R.S. Sir Henry Dyke Acland, Bart., M.D., F.R.S., Regius Professor of Medicine The Rev. B. Price, D.D., F.R.S., Sedleian Professor of Natural Philosophy Dr. J. J. Sylvester, F.R.S., Savilian Professor of Geometry	Gilbert C. Bourne, Esq., M.A. G. C. Druce, Esq., M.A. D. H. Nagel, Esq., M.A.

CAPTAIN SIR DOUGLAS GALTON, K.C.B., D.C.L., LL.D., F.R.S., F.R.G.S., F.G.S. IPSWICH, September 11, 1895.	The Most Hon. the Marquis of Bristol, M.A., Lord-Lieutenant of the County of Suffolk The Right Hon. Lord Walsingham, LL.D., F.R.S., High Steward of the University of Cambridge The Right Hon. Lord Rayleigh, Sec.R.S., Lord-Lieutenant of Essex The Right Hon. Lord Gwydyr, M.A., High Steward of Ipswich The Right Hon. Lord Henniker, F.S.A. The Right Hon. Lord Rendlesham J. H. Bartlet, Esq., Mayor of Ipswich Sir G. G. Stokes, Bart., D.C.L., F.R.S. Dr. E. Frankland, D.C.L., F.R.S. Professor G. H. Darwin, M.A., F.R.S. Felix T. Cobbold, Esq., M.A.	G. H. Hewetson, Esq. S. A. Notcutt, Esq., B.A., LL.M., B.Sc. E. P. Ridley, Esq.
SIR JOSEPH LISTER, Bart., D.C.L., LL.D., President of the Royal Society LIVERPOOL, September 16, 1896.	The Right Hon. the Earl of Derby, G.C.B., Lord Mayor of Liverpool The Right Hon. the Earl of Sefton, K.G., Lord-Lieutenant of Lancashire Sir W. B. Forwood, J.P. Sir Henry E. Roscoe, D.C.L., F.R.S The Principal of University College, Liverpool W. Rathbone, Esq., LL.D. W. Crookes, Esq., F.R.S., V.P.C.S. T. H. Ismay, Esq., J.P., D.L. Professor A. Liversidge, F.R.S.	Professor W. A. Herdman, F.R.S. Isaac C. Thompson, Esq., F.L.S. W. E. Willink, Esq.
SIR JOHN EVANS, K.C.B., D.C.L., LL.D., Sc.D., Treas.R.S., F.S.A., For.Sec.G.S. TORONTO, August 18, 1897.	His Excellency the Right Hon. the Earl of Aberdeen, G.C.M.G., Governor-General of the Dominion of Canada The Right Hon. Lord Rayleigh, M.A., D.C.L., F.R.S. The Right Hon. Lord Kelvin, G.C.V.O., D.C.L., LL.D., F.R.S., F.R.S.E. The Hon. Sir Wilfrid Laurier, G.C.M.G., Prime Minister of the Dominion of Canada His Honour the Lieutenant-Governor of the Province of Ontario The Hon. the Premier of the Province of Ontario The Hon. the Minister of Education for the Province of Ontario The Hon. Sir Charles Tupper, Bart., G.C.M.G., C.B., LL.D. The Hon. Sir Donald A. Smith, G.C.M.G., LL.D., High Commissioner for Canada Sir William Dawson, C.M.G., F.R.S. The Mayor of Toronto Professor J. Loudon, M.A., LL.D., President of the University of Toronto	Professor A. B. Macallum, M.B., Ph.D. B. E. Walker, Esq., F.G.S. J. S. Willison, Esq.
SIR WILLIAM CROOKES, F.R.S., V.P.C.S. BRISTOL, September 7, 1898.	The Right Hon. the Earl of Ducie, F.R.S., F.G.S. The Right Rev. the Lord Bishop of Bristol, D.D. The Right Hon. Sir Edward Fry, D.C.L., F.R.S., F.S.A. Sir F. J. Bramwell, Bart., D.C.L., LL.D., F.R.S. The Right Worshipful the Mayor of Bristol The Principal of University College, Bristol The Master of the Society of Merchant Venturers of Bristol John Beddoe, Esq., M.D., LL.D., F.R.S. Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.S.A., F.G.S.	Arthur Lee, Esq., J.P. Bertram Rogers, Esq., M.D.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
PROFESSOR SIR MICHAEL FOSTER, K.C.B., M.D., D.C.L., LL.D., Sec. R.S. DOVER, September 13, 1899.	His Grace the Lord Archbishop of Canterbury, D.D. The Most Hon. the Marquis of Salisbury, K.G., M.A., D.C.L., F.R.S. The Mayor of Dover The Major-General Commanding the South-Eastern District The Right Hon. A. Akers-Douglas, M.P. The Very Rev. F. W. Farrar, D.D., F.R.S., Dean of Canterbury Sir J. Norman Lockyer, K.C.B., F.R.S. Professor G. H. Darwin, M.A., LL.D., F.R.S., Pres. R.A.S.	E. Wollaston Knocker, Esq., C.B. W. H. Pendlebury, Esq., M.A.
PROFESSOR SIR WILLIAM TURNER, M.B., D.Sc, D.C.L., LL.D., F.R.S. BRADFORD, September 5, 1900.	The Right Hon. the Earl of Scarbrough, Lord-Lieutenant of the West Riding of Yorkshire His Grace the Duke of Devonshire, K.G., D.C.L., LL.D., F.R.S. The Most Hon. the Marquis of Ripon, K.G., G.C.S.I., D.C.L., F.R.S. The Right Rev. the Lord Bishop of Ripon, D.D. The Right Hon. Lord Masham His Worship the Mayor of Bradford The Hon. H. E. Butler, Lord of the Manor, Bradford Sir Alexander Binnie, M.Inst.C.E., F.G.S. Professor A. W. Rücker, M.A., D.Sc., Sec.R.S. Dr. T. E. Thorpe, Sc.D., F.R.S., Pres.C.S. Principal N. Bodington, Litt D., Vice-Chancellor of the Victoria University Professor L. C. Miall, F.R.S.	Ramsden Bacchus, Esq. J. E. Fawcett, Esq., J.P. Frederick Stevens, Esq.
PROFESSOR A. W. RÜCKER, M.A., LL.D., D.Sc., Sec.R.S. GLASGOW, September 11, 1901.	The Right Hon. the Earl of Glasgow, G.C.M.G. The Right Hon. the Lord Blythswood, LL.D., D.L. The Right Hon. the Lord Kelvin, G.C.V.O., D.C.L., LL.D., F.R.S. Samuel Chisholm, Esq., the Hon. the Lord Provost of Glasgow Very Rev. R. Herbert Story, D.D., LL.D., Principal of the University of Glasgow Sir John Maxwell Stirling-Maxwell, Bart., M.P., D.L. Sir Andrew Noble, K.C.B., D.C.L., F.R.S. Sir Archibald Geikie, D.C.L., LL.D., F.R.S. Sir W. T. Thiselton-Dyer, K.C.M.G., C.I.E., F.R.S. James Parker Smith, Esq., M.P., D.L. John Inglis, Esq., LL.D. Professor John Cleland, M.D., LL.D., D.Sc., F.R.S.	Sir J. D. Marwick, LL.D., D.L., F.R.S.E. Professor John Young, M.D. Professor Magnus Maclean, D.Sc., F.R.S.E.

Presidents	Vice-Presidents	Local Secretaries
PROFESSOR JAMES DEWAR, M.A., LL.D., D.Sc., F.R.S. BELFAST, September 10, 1902.	His Grace the Duke of Abercorn, K.G., H.M. Lieutenant of the County of Donegal The Marquis of Londonderry, K.G., H.M. Lieutenant of the City of Belfast Sir Francis Macnaghten, Bart., H.M. Lieutenant of the County of Antrim The Right Hon. the Earl of Shaftesbury, D.L. The Right Hon. the Earl of Rosse, K.P., D.C.L., LL.D., F.R.S. The Right Hon. Thomas Sinclair, D.Lit. Sir William Quartus Ewart, Bart., M.A. The Lord Mayor of Belfast The President of Queen's College, Belfast Professor E. Ray Lankester, M.A., F.R.S. Professor Peter Redfern, M.D.	John Brown, Esq., F.R.S. Godfrey W. Ferguson, Esq. Professor Maurice FitzGerald, B.A.
SIR NORMAN LOCKYER, K.C.B., LL.D., F.R.S., Correspondant de l'Institut de France SOUTHPORT, September 9, 1903.	The Right Hon. the Earl of Derby, K.G., G.C.B. The Right Hon. the Earl of Crawford and Balcarres, K.T., LL.D., F.R.S. The Right Hon. the Earl Spencer, K.G., LL.D., Chancellor of the Victoria University The Right Hon. the Earl of Sefton The Right Hon. the Earl of Lathom Sir Henry Roscoe, B.A., Ph.D., LL.D., D.C.L., F.R.S. Sir George A. Pilkington Alfred Hopkinson, Esq., LL.D., K.C., Vice-Chancellor of the Victoria University T. T. L. Scarisbrick, Esq., Mayor of Southport E. Marshall Hall, Esq., K.C., M.P. for Southport Charles H. B. Hesketh, Esq. Charles Scarisbrick, Esq., J.P. Charles Weld Blundell, Esq.	Harold Brodrick, Esq., M.A. J. Ernest Jarratt, Esq.
The RIGHT HON. A. J. BALFOUR, D.C.L., LL.D., M.P., F.R.S., Chancellor of the University of Edinburgh CAMBRIDGE, August 17, 1904.	His Grace the Duke of Devonshire, K.G., LL.D., F.R.S., Chancellor of the University of Cambridge Alexander Peckover, Esq., LL.D., Lord Lieutenant of Cambridgeshire Arthur Hall, Esq., M.A., D.L., High Sheriff of Cambridgeshire and Huntingdonshire The Right Rev. the Lord Bishop of Ely, D.D. The Right Hon. Lord Walsingham, LL.D., F.R.S., High Steward of the University of Cambridge The Right Hon. Lord Rayleigh, D.C.L., LL.D., F.R.S. The Right Hon. Lord Kelvin, G.C.V.O., D.C.L., LL.D., F.R.S. The Rev. F. H. Chase, D.D., Vice-Chancellor of the University and President of Queen's College, Cambridge The Very Rev. H. Montagu Butler, D.D., Master of Trinity Mrs. Sidgwick, Principal of Newnham College, Cambridge J. H. Chesshyre Dalton, Esq., M.D., Mayor of Cambridge Robert Stephenson, Esq., Chairman of the Cambridgeshire County Council Joseph Martin, Esq., Chairman of the Isle of Ely County Council P. H. Young, Esq., Deputy Mayor of Cambridge	S. R. Ginn, Esq., D.L. A. Hutchinson, Esq., M.A. A. C. Seward, Esq., M.A., F.R.S. S. Skinner, Esq., M.A. J. E. L. Whitehead, Esq., M.A.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
PROFESSOR G. H. DARWIN, M.A., LL.D., Ph.D., F.R.S. SOUTH AFRICA, August 15, 1905.	His Excellency the Right Hon. the Earl of Selborne, G.C.M.G., High Commissioner for South Africa The Right Hon. Lord Milner, G.C.B., G.C.M.G., late High Commissioner for South Africa His Excellency the Hon. Sir Walter F. Hely-Hutchinson, G.C.M.G., Governor of Cape Colony His Excellency Colonel Sir Henry E. McCallum, K.C.M.G., R.E., Governor of Natal His Excellency Captain the Hon. Sir Arthur Lawley, K.C.M.G., Lieutenant-Governor, Transvaal His Excellency Major Sir H. J. Goold-Adams, K.C.M.G., Lieutenant-Governor, Orange River Colony His Honour Sir W. H. Milton, K.C.M.G., Administrator of Southern Rhodesia Sir Charles H. T. Metcalfe, Bart., M.A. Sir David Gill, K.C.B., LL.D., F.R.S., H.M. Astronomer, Cape Colony Theodore Reunert, M.Inst.C.E. The Mayor of Cape Town The Mayor of Johannesburg The President of the Philosophical Society of South Africa The Mayor of Durban The Mayor of Pietermaritzburg The Mayor of Bloemfontein The Mayor of Pretoria The Mayor of Kimberley The Mayor of Bulawayo	*Cape Town:—* Professor J. C. Beattie, D.Sc., F.R.S.E. E. J. Cattell, J.P. J. R. Finch. Rev. Wm. Flint, D.D. E. H. Jones. W. L. Sclater, M.A. *Johannesburg:—* W. E. Cursons. F. Rowland. *Central Organising Committee for South Africa:—* *Chairman.*—Sir David Gill, K.C.B., F.R.S. *Hon. Secretaries.*—J. D. F. Gilchrist, M.A., Ph.D. (Cape Town); W. Cullen (Johannesburg).

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1883–95 Sir DOUGLAS GALTON, F.R.S., and A. G. VERNON HARCOURT, Esq., F.R.S.
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1897–1900 Prof. SCHÄFER, F.R.S., and Sir W. C. ROBERTS-AUSTEN, F.R.S.
1900–02 Sir W. C. ROBERTS-AUSTEN, F.R.S., and Dr. D. H. SCOTT, F.R.S.
1902–03 Dr. D. H. SCOTT, F.R.S., and Major P. A. MACMAHON, F.R.S.
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1885–90 A. T. ATCHISON, Esq., M.A., *Secretary.*
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Date and Place	Presidents	Secretaries

MATHEMATICAL AND PHYSICAL SCIENCES.

COMMITTEE OF SCIENCES, I.—MATHEMATICS AND GENERAL PHYSICS.

1832. Oxford	Davies Gilbert, D.C.L., F.R.S.	Rev. H. Coddington.
1833. Cambridge	Sir D. Brewster, F.R.S.	Prof. Forbes.
1834. Edinburgh	Rev. W. Whewell, F.R.S.	Prof. Forbes, Prof. Lloyd.

SECTION A.—MATHEMATICS AND PHYSICS.

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1837. Liverpool...	Sir D. Brewster, F.R.S.	W. S. Harris, Rev. Prof. Powell, Prof. Stevelly.
1838. Newcastle	Sir J. F. W. Herschel, Bart., F.R.S.	Rev. Prof. Chevallier, Major Sabine, Prof. Stevelly.
1839. Birmingham	Rev. Prof. Whewell, F.R.S....	J. D. Chance, W. Snow Harris, Prof. Stevelly.
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1841. Plymouth	Rev. Prof. Lloyd, F.R.S.......	Prof. Stevelly.
1842. Manchester	Very Rev. G. Peacock, D.D., F.R.S.	Prof. M'Culloch, Prof. Stevelly, Rev. W. Scoresby.
1843. Cork	Prof. M'Culloch, M.R.I.A. ...	J. Nott, Prof. Stevelly.
1844. York	The Earl of Rosse, F.R.S. ...	Rev. Wm. Hey, Prof. Stevelly.
1845. Cambridge	The Very Rev. the Dean of Ely.	Rev. H. Goodwin, Prof. Stevelly, G. G. Stokes.
1846. Southampton.	Sir John F. W. Herschel, Bart., F.R.S.	John Drew, Dr. Stevelly, G. G. Stokes.
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1848. Swansea ...	Lord Wrottesley, F.R.S.	Dr. Stevelly, G. G. Stokes.
1849. Birmingham	William Hopkins, F.R.S.......	Prof. Stevelly, G. G. Stokes, W. Ridout Wills.
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1868. Norwich ...	Prof. J. Tyndall, LL.D., F.R.S.	Prof. G. C. Foster, Rev. R. Harley, R. B. Hayward.
1869. Exeter......	Prof. J. J. Sylvester, LL.D., F.R.S.	Prof. G. C. Foster, R. B. Hayward, W. K. Clifford.
1870. Liverpool...	J. Clerk Maxwell, M.A., LL.D., F.R.S.	Prof. W. G. Adams, W. K. Clifford, Prof. G. C. Foster, Rev. W. Allen Whitworth.
1871. Edinburgh	Prof. P. G. Tait, F.R.S.E. ...	Prof. W. G. Adams, J. T. Bottomley, Prof. W. K. Clifford, Prof. J. D. Everett, Rev. R. Harley.
1872. Brighton ...	W. De La Rue, D.C.L., F.R.S.	Prof. W. K. Clifford, J. W. L. Glaisher, Prof. A. S. Herschel, G. F. Rodwell.
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1876. Glasgow ...	Prof. Sir W. Thomson, M.A., D.C.L., F.R.S.	Prof. W. F. Barrett, J. T. Bottomley, Prof. G. Forbes, J. W. L. Glaisher, T. Muir.
1877. Plymouth...	Prof. G. C. Foster, B.A., F.R.S., Pres. Physical Soc.	Prof. W. F. Barrett, J. T. Bottomley, J. W. L. Glaisher, F. G. Landon.
1878. Dublin.. ..	Rev. Prof. Salmon, D.D., D.C.L., F.R.S.	Prof. J. Casey, G. F. Fitzgerald, J. W. L. Glaisher, Dr. O. J. Lodge.
1879. Sheffield ...	George Johnstone Stoney, M.A., F.R.S.	A. H. Allen, J. W. L. Glaisher, Dr. O. J. Lodge, D. MacAlister.
1880. Swansea ...	Prof. W. Grylls Adams, M.A., F.R.S.	W. E. Ayrton, J. W. L. Glaisher, Dr. O. J. Lodge, D. MacAlister.
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1886. Birmingham	Prof. G. H. Darwin, M.A., LL.D., F.R.S.	R. E. Baynes, R. T. Glazebrook, Prof. J. H. Poynting, W. N. Shaw.

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1888. Bath	Prof. G. F. Fitzgerald, M.A., F.R.S.	R. E. Baynes, R. T. Glazebrook, A. Lodge, W. N. Shaw.
1889. Newcastle-upon-Tyne	Capt. W. de W. Abney, C.B., R.E., F.R.S.	R. E. Baynes, R. T. Glazebrook, A. Lodge, W. N. Shaw, H. Stroud.
1890. Leeds	J. W. L. Glaisher, Sc.D., F.R.S., V.P.R.A.S.	R. T. Glazebrook, Prof. A. Lodge, W. N. Shaw, Prof. W. Stroud.
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1892. Edinburgh	Prof. A. Schuster, Ph.D., F.R.S., F.R.A.S.	R. E. Baynes, J. Larmor, Prof. A. Lodge, Dr. W. Peddie.
1893. Nottingham	R. T. Glazebrook, M.A., F.R.S.	W. T. A. Emtage, J. Larmor, Prof. A. Lodge, Dr. W. Peddie.
1894. Oxford	Prof. A. W. Rücker, M.A., F.R.S.	Prof. W. H. Heaton, Prof. A. Lodge, J. Walker.
1895. Ipswich ...	Prof. W. M. Hicks, M.A., F.R.S.	Prof. W. H. Heaton, Prof. A. Lodge, G. T. Walker, W. Watson.
1896. Liverpool...	Prof. J. J. Thomson, M.A., D.Sc., F.R.S.	Prof. W. H. Heaton, J. L. Howard, Prof. A. Lodge, G. T. Walker, W. Watson.
1897. Toronto ...	Prof. A. R. Forsyth, M.A., F.R.S.	Prof. W. H. Heaton, J. C. Glashan, J. L. Howard, Prof. J. C. McLennan.
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1899. Dover	Prof. J. H. Poynting, F.R.S.	J. L. Howard, C. H. Lees, W. Watson, E. T. Whittaker.
1900. Bradford ...	Dr. J. Larmor, F.R.S.—*Dep. of Astronomy*, Dr. A. A. Common, F.R.S.	P. H. Cowell, A. Fowler, C. H. Lees, C. J. L. Wagstaffe, W. Watson, E. T. Whittaker.
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1902. Belfast	Prof. J. Purser, LL.D., M.R.I.A. —*Dep. of Astronomy*, Prof. A. Schuster, F.R.S.	H. S. Carslaw, A. R. Hinks, A. Larmor, C. H. Lees, Prof. W. B. Morton, A. W. Porter.
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1904. Cambridge	Prof. H. Lamb, F.R.S.—*Sub-Section of Astronomy and Cosmical Physics*, Sir J. Eliot, K.C.I.E., F.R.S.	A. R. Hinks, R. W. H. T. Hudson, Dr. C. H. Lees, Dr. W. J. S. Lockyer, A. W. Porter, W. C. D. Whetham.
1905. SouthAfrica	Prof. A. R. Forsyth, M.A., F.R.S.	A. R. Hinks, S. S. Hough, R. T. A. Innes, J. H. Jeans, Dr. C. H. Lees.

CHEMICAL SCIENCE.

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1833. Cambridge	John Dalton, D.C.L., F.R.S.	Prof. Miller.
1834. Edinburgh	Dr. Hope	Mr. Johnston, Dr. Christison.

SECTION B.—CHEMISTRY AND MINERALOGY.

1835. Dublin	Dr. T. Thomson, F.R.S.	Dr. Apjohn, Prof. Johnston.
1836. Bristol	Rev. Prof. Cumming	Dr. Apjohn, Dr. C. Henry, W. Herapath.
1837. Liverpool...	Michael Faraday, F.R.S.......	Prof. Johnston, Prof. Miller, Dr. Reynolds.

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1838 Newcastle	Rev. William Whewell, F.R.S.	Prof. Miller, H. L. Pattinson, Thomas Richardson.
1839. Birmingham	Prof. T. Graham, F.R.S.	Dr. Golding Bird, Dr. J. B. Melson.
1840. Glasgow ...	Dr. Thomas Thomson, F.R.S.	Dr. R. D. Thomson, Dr. T. Clark, Dr. L. Playfair.
1841. Plymouth...	Dr. Daubeny, F.R.S.	J. Prideaux, R. Hunt, W. M. Tweedy.
1842. Manchester	John Dalton, D.C.L., F.R.S.	Dr. L. Playfair, R. Hunt, J. Graham.
1843. Cork.........	Prof. Apjohn, M.R.I.A.........	R. Hunt, Dr. Sweeny.
1844. York.........	Prof. T. Graham, F.R.S.	Dr. L. Playfair, E. Solly, T. H. Barker.
1845. Cambridge	Rev. Prof. Cumming	R. Hunt, J. P. Joule, Prof. Miller, E. Solly.
1846. Southampton.	Michael Faraday, D.C.L., F.R.S.	Dr. Miller, R. Hunt, W. Randall.
1847. Oxford......	Rev. W. V. Harcourt, M.A., F.R.S.	B. C. Brodie, R. Hunt, Prof. Solly.
1848. Swansea ...	Richard Phillips, F.R.S.	T. H. Henry, R. Hunt, T. Williams.
1849. Birmingham	John Percy, M.D., F.R.S.......	R. Hunt, G. Shaw.
1850. Edinburgh	Dr. Christison, V.P.R.S.E. ...	Dr. Anderson, R. Hunt, Dr. Wilson.
1851. Ipswich ...	Prof. Thomas Graham, F.R.S.	T. J. Pearsall, W. S. Ward.
1852. Belfast......	Thomas Andrews, M.D., F.R.S.	Dr. Gladstone, Prof. Hodges, Prof. Ronalds.
1853. Hull	Prof. J. F. W. Johnston, M.A., F.R.S.	H. S. Blundell, Prof. R. Hunt, T. J. Pearsall.
1854. Liverpool	Prof. W. A. Miller, M.D., F.R.S.	Dr. Edwards, Dr. Gladstone, Dr. Price.
1855. Glasgow ...	Dr. Lyon Playfair, C.B., F.R.S.	Prof. Frankland, Dr. H. E. Roscoe.
1856. Cheltenham	Prof. B. C. Brodie, F.R.S. ...	J. Horsley, P. J. Worsley, Prof. Voelcker.
1857. Dublin......	Prof. Apjohn, M.D., F.R.S., M.R.I.A.	Dr. Davy, Dr. Gladstone, Prof. Sullivan.
1858. Leeds	Sir J. F. W. Herschel, Bart., D.C.L.	Dr. Gladstone, W. Odling, R. Reynolds.
1859. Aberdeen...	Dr. Lyon Playfair, C.B., F.R.S.	J. S. Brazier, Dr. Gladstone, G. D. Liveing, Dr. Odling.
1860. Oxford......	Prof. B. C. Brodie, F.R.S......	A. Vernon Harcourt, G. D. Liveing, A. B. Northcote.
1861. Manchester	Prof. W. A. Miller, M.D., F.R.S.	A. Vernon Harcourt, G. D. Liveing.
1862. Cambridge	Prof. W. H. Miller, M.A., F.R.S.	H. W. Elphinstone, W. Odling, Prof. Roscoe.
1863. Newcastle	Dr. Alex. W. Williamson, F.R.S.	Prof. Liveing, H. L. Pattinson, J. C. Stevenson.
1864. Bath.........	W. Odling, M.B., F.R.S.......	A. V. Harcourt, Prof. Liveing, R. Biggs.
1865. Birmingham	Prof. W. A. Miller, M.D., V.P.R.S.	A. V. Harcourt, H. Adkins, Prof. Wanklyn, A. Winkler Wills.
1866. Nottingham	H. Bence Jones, M.D., F.R.S.	J. H. Atherton, Prof. Liveing, W. J. Russell, J. White.
1867. Dundee ...	Prof. T. Anderson, M.D., F.R.S.E.	A. Crum Brown, Prof. G. D. Liveing, W. J. Russell.
1868. Norwich ...	Prof. E. Frankland, F.R.S.	Dr. A. Crum Brown, Dr. W. J. Russell, F. Sutton.
1869. Exeter	Dr. H. Debus, F.R.S.	Prof. A. Crum Brown, Dr. W. J. Russell, Dr. Atkinson.
1870. Liverpool...	Prof. H. E. Roscoe, B.A., F.R.S.	Prof. A. Crum Brown, A. E. Fletcher, Dr. W. J. Russell.
1871. Edinburgh	Prof. T. Andrews, M.D., F.R.S.	J. Y. Buchanan, W. N. Hartley, T. E. Thorpe.
1872. Brighton ...	Dr. J. H. Gladstone, F.R.S....	Dr. Mills, W. Chandler Roberts, Dr. W. J. Russell, Dr. T. Wood.

Date and Place	Presidents	Secretaries
1873. Bradford ...	Prof. W. J. Russell, F.R.S....	Dr. Armstrong, Dr. Mills, W. Chandler Roberts, Dr. Thorpe.
1874. Belfast......	Prof. A. Crum Brown, M.D., F.R.S.E.	Dr. T. Cranstoun Charles, W. Chandler Roberts, Prof. Thorpe.
1875. Bristol	A. G. Vernon Harcourt, M.A., F.R.S.	Dr. H. E. Armstrong, W. Chandler Roberts, W. A. Tilden.
1876. Glasgow ...	W. H. Perkin, F.R.S.	W. Dittmar, W. Chandler Roberts, J. M. Thomson, W. A. Tilden.
1877. Plymouth...	F. A. Abel, F.R.S...............	Dr. Oxland, W. Chandler Roberts, J. M. Thomson.
1878. Dublin	Prof. Maxwell Simpson, M.D., F.R.S.	W. Chandler Roberts, J. M. Thomson, Dr. C. R. Tichborne, T. Wills.
1879. Sheffield ...	Prof. Dewar, M.A., F.R.S. ...	H. S. Bell, W. Chandler Roberts, J. M. Thomson.
1880. Swansea ...	Joseph Henry Gilbert, Ph.D., F.R.S.	P. P. Bedson, H. B. Dixon, W. R. E. Hodgkinson, J. M. Thomson.
1881. York.........	Prof. A. W. Williamson, F.R.S.	P. P. Bedson, H. B. Dixon, T. Gough.
1882. Southampton.	Prof. G. D. Liveing, M.A., F.R.S.	P. Phillips Bedson, H. B. Dixon, J. L. Notter.
1883. Southport	Dr. J. H. Gladstone, F.R.S...	Prof. P. Phillips Bedson, H. B. Dixon, H. Forster Morley.
1884. Montreal ...	Prof. Sir H. E. Roscoe, Ph.D., LL.D., F.R.S.	Prof. P. Phillips Bedson, H. B. Dixon, T. McFarlane, Prof. W. H. Pike.
1885. Aberdeen...	Prof. H. E. Armstrong, Ph.D., F.R.S., Sec. C.S.	Prof. P. Phillips Bedson, H. B. Dixon, H. Forster Morley, Dr. W. J. Simpson.
1886. Birmingham	W. Crookes, F.R.S., V.P.C.S.	P. P. Bedson, H. B. Dixon, H. F. Morley, W. W. J. Nicol, C. J. Woodward.
1887. Manchester	Dr. E. Schunck, F.R.S.	Prof. P. Phillips Bedson, H. Forster Morley, W. Thomson.
1888. Bath.........	Prof. W. A. Tilden, D.Sc., F.R.S., V.P.C.S.	Prof. H. B. Dixon, H. Forster Morley, R. E. Moyle, W. W. J. Nicol.
1889. Newcastle-upon-Tyne	Sir I. Lowthian Bell, Bart., D.C.L., F.R.S.	H. Forster Morley, D. H. Nagel, W. W. J. Nicol, H. L. Pattinson, jun.
1890. Leeds	Prof. T. E. Thorpe, B.Sc., Ph.D., F.R.S., Treas. C.S.	C. H. Bothamley, H. Forster Morley, D. H. Nagel, W. W. J. Nicol.
1891. Cardiff......	Prof. W. C. Roberts-Austen, C.B., F.R.S.	C. H. Bothamley, H. Forster Morley, W. W. J. Nicol, G. S. Turpin.
1892. Edinburgh	Prof. H. McLeod, F.R.S.......	J. Gibson, H. Forster Morley, D. H. Nagel, W. W. J. Nicol.
1893. Nottingham	Prof. J. Emerson Reynolds, M.D., D.Sc., F.R.S.	J. B. Coleman, M. J. R. Dunstan, D. H. Nagel, W. W. J. Nicol.
1894. Oxford......	Prof. H. B. Dixon, M.A., F.R.S.	A. Colefax, W. W. Fisher, Arthur Harden, H. Forster Morley.

SECTION B (*continued*).—CHEMISTRY.

1895. Ipswich ...	Prof. R. Meldola, F.R.S.	E. H. Fison, Arthur Harden, C. A. Kohn, J. W. Rodger.
1896. Liverpool...	Dr. Ludwig Mond, F.R.S. ...	Arthur Harden, C. A. Kohn.
1897 Toronto ...	Prof. W. Ramsay, F.R.S.......	Prof. W. H. Ellis, A. Harden, C. A. Kohn, Prof. R. F. Ruttan.
1898. Bristol	Prof. F. R. Japp, F.R.S.	C. A. Kohn, F. W. Stoddart, T. K. Rose.
1899. Dover	Horace T. Brown, F.R.S.......	A. D. Hall, C. A. Kohn, T. K. Rose, Prof. W. P. Wynne.
1900. Bradford ...	Prof. W. H. Perkin, F.R.S. ...	W. M. Gardner, F. S. Kipping, W. J. Pope, T. K. Rose.
1901. Glasgow ...	Prof. Percy F. Frankland, F.R.S.	W. C. Anderson, G. G. Henderson, W. J. Pope, T. K. Rose.

Date and Place	Presidents	Secretaries
1902. Belfast......	Prof. E. Divers, F.R.S..........	R. F. Blake, M. O. Forster, Prof, G. G. Henderson, Prof. W. J. Pope,
1903. Southport	Prof. W. N. Hartley, D.Sc., F.R.S.	Dr. M. O. Forster, Prof. G. G. Henderson, J. Ohm, Prof. W. J. Pope.
1904. Cambridge	Prof. Sydney Young, F.R.S....	Dr. M. O. Forster, Prof. G. G. Henderson, Dr. H. O. Jones, Prof. W. J. Pope.
1905. SouthAfrica	George T. Beilby	W. A. Caldecott, Dr. M. O. Forster, Prof. G. G. Henderson, C. F. Juritz,

GEOLOGICAL (AND, UNTIL 1851, GEOGRAPHICAL) SCIENCE.

COMMITTEE OF SCIENCES, III.—GEOLOGY AND GEOGRAPHY.

1832. Oxford......	R. I. Murchison, F.R.S.	John Taylor.
1833. Cambridge.	G. B. Greenough, F.R.S.	W. Lonsdale, John Phillips.
1834. Edinburgh.	Prof. Jameson	J. Phillips, T. J. Torrie, Rev. J. Yates,

SECTION C.—GEOLOGY AND GEOGRAPHY.

1835. Dublin......	R. J. Griffith	Captain Portlock, T. J. Torrie.
1836. Bristol......	Rev. Dr. Buckland, F.R.S.—*Geog.*, R. I. Murchison, F.R.S.	William Sanders, S. Stutchbury, T. J. Torrie.
1837. Liverpool...	Rev. Prof. Sedgwick, F.R.S.—*Geog.*, G. B. Greenough, F.R.S.	Captain Portlock, R. Hunter.—*Geography*, Capt. H. M. Denham, R.N.
1838. Newcastle.	C. Lyell, F.R.S., V.P.G.S.—*Geography*, Lord Prudhoe.	W. C. Trevelyan, Capt. Portlock.—*Geography*, Capt. Washington.
1839. Birmingham	Rev. Dr. Buckland, F.R.S.—*Geog.*, G. B. Greenough, F.R.S.	George Lloyd, M.D., H. E. Strickland, Charles Darwin.
1840. Glasgow ...	Charles Lyell, F.R.S.—*Geog.*, G. B. Greenough, F.R.S.	W. J. Hamilton, D. Milne, H. Murray, H. E. Strickland, J. Scoular.
1841. Plymouth...	H. T. De la Beche, F.R.S. ...	W. J. Hamilton, Edward Moore, M.D., R. Hutton.
1842. Manchester	R. I. Murchison, F.R.S.	E. W. Binney, R. Hutton, Dr. R. Lloyd, H. E. Strickland.
1843. Cork.........	Richard E. Griffith, F.R.S. ...	F. M. Jennings, H. E. Strickland.
1844. York.........	Henry Warburton, Pres. G. S.	Prof. Ansted, E. H. Bunbury.
1845. Cambridge.	Rev. Prof. Sedgwick, M.A. F.R.S.	Rev. J. C. Cumming, A. C. Ramsay, Rev. W. Thorp.
1846. Southampton.	Leonard Horner, F.R.S.	Robert A. Austen, Dr. J. H. Norton, Prof. Oldham, Dr. C. T. Beke.
1847. Oxford......	Very Rev. Dr. Buckland, F.R.S.	Prof. Ansted, Prof. Oldham, A. C. Ramsay, J. Ruskin.
1848. Swansea ...	Sir H. T. De la Beche, F.R.S.	S. Benson, Prof. Oldham, Prof. Ramsay
1849. Birmingham	Sir Charles Lyell, F.R.S.......	J. B. Jukes, Prof. Oldham, A. C. Ramsay.
1850. Edinburgh[1]	Sir Roderick I. Murchison, F.R.S.	A. Keith Johnston, Hugh Miller, Prof. Nicol.

SECTION C (*continued*).—GEOLOGY.

1851. Ipswich ...	William Hopkins, M.A., F.R.S.	C. J. F. Bunbury, G. W. Ormerod, Searles Wood.
1852. Belfast......	Lieut.-Col. Portlock, R.E., F.R.S.	James Bryce, James MacAdam, Prof. M'Coy, Prof. Nicol.
1853. Hull.........	Prof. Sedgwick, F.R.S.........	Prof. Harkness, William Lawton.
1854. Liverpool..	Prof. Edward Forbes, F.R.S.	John Cunningham, Prof. Harkness, G. W. Ormerod, J. W. Woodall,

[1] Geography was constituted a separate Section, see page lxiv.

Date and Place	Presidents	Secretaries
1855. Glasgow ...	Sir R. I. Murchison, F.R.S....	J. Bryce, Prof. Harkness, Prof. Nicol.
1856. Cheltenham	Prof. A. C. Ramsay, F.R.S....	Rev. P. B. Brodie, Rev. R. Hepworth, Edward Hull, J. Scougall, T. Wright.
1857. Dublin	The Lord Talbot de Malahide	Prof. Harkness, G. Sanders, R. H. Scott.
1858. Leeds	William Hopkins, M.A., F.R.S.	Prof. Nicol, H. C. Sorby, E. W. Shaw.
1859. Aberdeen...	Sir Charles Lyell, LL.D., D.C.L., F.R.S.	Prof. Harkness, Rev. J. Longmuir, H. C. Sorby.
1860. Oxford	Rev. Prof. Sedgwick, F.R.S...	Prof. Harkness, E. Hull, J. W. Woodall.
1861. Manchester	Sir R. I. Murchison, D.C.L., LL.D., F.R.S.	Prof. Harkness, Edward Hull, T. Rupert Jones, G. W. Ormerod.
1862. Cambridge	J. Beete Jukes, M.A., F.R.S.	Lucas Barrett, Prof. T. Rupert Jones, H. C. Sorby.
1863. Newcastle	Prof. Warington W. Smyth, F.R.S., F.G.S.	E. F. Boyd, John Daglish, H. C. Sorby, Thomas Sopwith.
1864. Bath	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	W. B. Dawkins, J. Johnston, H. C. Sorby, W. Pengelly.
1865. Birmingham	Sir R. I. Murchison, Bart., K.C.B., F.R.S.	Rev. P. B. Brodie, J. Jones, Rev. E. Myers, H. C. Sorby, W. Pengelly.
1866. Nottingham	Prof. A. C. Ramsay, LL.D., F.R.S.	R. Etheridge, W. Pengelly, T. Wilson, G. H. Wright.
1867. Dundee ...	Archibald Geikie, F.R.S.......	E. Hull, W. Pengelly, H. Woodward.
1868. Norwich ...	R. A. C. Godwin-Austen, F.R.S., F.G.S.	Rev. O. Fisher, Rev. J. Gunn, W. Pengelly, Rev. H. H. Winwood.
1869. Exeter	Prof. R. Harkness, F.R.S., F.G.S.	W. Pengelly, W. Boyd Dawkins, Rev. H. H. Winwood.
1870. Liverpool...	Sir Philip de M. Grey Egerton, Bart., M.P., F.R.S.	W. Pengelly, Rev. H. H. Winwood, W. Boyd Dawkins, G. H. Morton.
1871. Edinburgh	Prof. A. Geikie, F.R.S., F.G.S.	R. Etheridge, J. Geikie, T. McKenny Hughes, L. C. Miall.
1872. Brighton ...	R. A. C. Godwin-Austen, F.R.S., F.G.S.	L. C. Miall, George Scott, William Topley, Henry Woodward.
1873. Bradford ...	Prof. J. Phillips, F.R.S.	L. C. Miall, R. H. Tiddeman, W. Topley.
1874. Belfast......	Prof. Hull, M.A., F.R.S., F.G.S.	F. Drew, L. C. Miall, R. G. Symes, R. H. Tiddeman.
1875. Bristol	Dr. T. Wright, F.R.S.E., F.G.S.	L. C. Miall, E. B. Tawney, W. Topley.
1876. Glasgow ...	Prof. John Young, M.D.	J. Armstrong, F. W. Rudler, W. Topley.
1877. Plymouth...	W. Pengelly, F.R.S., F.G.S.	Dr. Le Neve Foster, R. H. Tiddeman, W. Topley.
1878. Dublin......	John Evans, D.C.L., F.R.S., F.S.A., F.G.S.	E. T. Hardman, Prof. J. O'Reilly, R. H. Tiddeman.
1879. Sheffield ...	Prof. P. M. Duncan, F.R.S.	W. Topley, G. Blake Walker.
1880. Swansea ...	H. C. Sorby, F.R.S., F.G.S....	W. Topley, W. Whitaker.
1881. York.........	A. C. Ramsay, LL.D., F.R.S., F.G.S.	J. E. Clark, W. Keeping, W. Topley, W. Whitaker.
1882. Southampton.	R. Etheridge, F.R.S., F.G.S.	T. W. Shore, W. Topley, E. Westlake, W. Whitaker.
1883. Southport	Prof. W. C. Williamson, LL.D., F.R.S.	R. Betley, C. E. De Rance, W. Topley, W. Whitaker.
1884. Montreal ...	W. T. Blanford, F.R.S., Sec. G.S.	F. Adams, Prof. E. W. Claypole, W. Topley, W. Whitaker.
1885. Aberdeen ...	Prof. J. W. Judd, F.R.S., Sec. G.S.	C. E. De Rance, J. Horne, J. J. H. Teall, W. Topley.
1886. Birmingham	Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.	W. J. Harrison, J. J. H. Teall, W. Topley, W. W. Watts.
1887. Manchester	Henry Woodward, LL.D., F.R.S., F.G.S.	J. E. Marr, J. J. H. Teall, W. Topley, W. W. Watts.

Date and Place	Presidents	Secretaries
1888. Bath.........	Prof. W. Boyd Dawkins, M.A., F.R.S., F.G.S.	Prof. G. A. Lebour, W. Topley, W. W. Watts, H. B. Woodward.
1889. Newcastle-upon-Tyne	Prof. J. Geikie, LL.D., D.C.L., F.R.S., F.G.S.	Prof. G. A. Lebour, J. E. Marr, W. W. Watts, H. B. Woodward.
1890. Leeds	Prof. A. H. Green, M.A., F.R.S., F.G.S.	J. E. Bedford, Dr. F. H. Hatch, J. E. Marr, W. W. Watts.
1891. Cardiff......	Prof. T. Rupert Jones, F.R.S., F.G.S.	W. Galloway, J. E. Marr, Clement Reid, W. W. Watts.
1892. Edinburgh	Prof. C. Lapworth, LL.D., F.R.S., F.G.S.	H. M. Cadell, J. E. Marr, Clement Reid, W. W. Watts.
1893. Nottingham	J. J. H. Teall, M.A., F.R.S., F.G.S.	J. W. Carr, J. E. Marr, Clement Reid, W. W. Watts.
1894. Oxford......	L. Fletcher, M.A., F.R.S. ...	F. A. Bather, A. Harker, Clement Reid, W. W. Watts.
1895. Ipswich ...	W. Whitaker, B.A., F.R.S. ...	F. A. Bather, G. W. Lamplugh, H. A. Miers, Clement Reid.
1896. Liverpool...	J. E. Marr, M.A., F.R.S.	J. Lomas, Prof. H. A. Miers, C. Reid.
1897. Toronto ...	Dr. G. M. Dawson, C.M.G., F.R.S.	Prof. A. P. Coleman, G. W. Lamplugh, Prof. H. A. Miers.
1898. Bristol......	W. H. Hudleston, F.R.S.	G. W. Lamplugh, Prof. H. A. Miers, H. Pentecost.
1899. Dover	Sir Archibald Geikie, F.R.S.	J. W. Gregory, G. W. Lamplugh, Capt. McDakin, Prof. H. A. Miers.
1900. Bradford ...	Prof. W. J. Sollas, F.R.S. ...	H. L. Bowman, Rev. W. L. Carter, G. W. Lamplugh, H. W. Monckton.
1901. Glasgow ...	John Horne, F.R.S.	H. L. Bowman, H. W. Monckton.
1902. Belfast......	Lieut.-Gen. C. A. McMahon, F.R.S.	H. L. Bowman, H. W. Monckton, J. St. J. Phillips, H. J. Seymour.
1903. Southport	Prof. W. W. Watts, M.A., M.Sc.	H. L. Bowman, Rev. W. L. Carter, J. Lomas, H. W. Monckton.
1904. Cambridge	Aubrey Strahan, F.R.S.	H. L. Bowman, Rev. W. L. Carter, J. Lomas, H. Woods.
1905. SouthAfrica	Prof. H. A. Miers, M.A., D.Sc., F.R.S.	H. L. Bowman, J. Lomas, Dr. Molengraaff, Prof. A. Young, Prof. R. B. Young.

BIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, IV.—ZOOLOGY, BOTANY, PHYSIOLOGY, ANATOMY.

1832. Oxford......	Rev. P. B. Duncan, F.G.S. ...	Rev. Prof. J. S. Henslow.
1833. Cambridge[1]	Rev. W. L. P. Garnons, F.L.S.	C. C. Babington, D. Don.
1834. Edinburgh.	Prof. Graham......................	W. Yarrell, Prof. Burnett.

SECTION D.—ZOOLOGY AND BOTANY.

1835. Dublin......	Dr. Allman........................	J. Curtis, Dr. Litton.
1836. Bristol......	Rev. Prof. Henslow	J. Curtis, Prof. Don, Dr. Riley, S. Rootsey.
1837. Liverpool...	W. S. MacLeay..................	C. C. Babington, Rev. L. Jenyns, W. Swainson.
1838. Newcastle	Sir W. Jardine, Bart.	J. E. Gray, Prof. Jones, R. Owen, Dr. Richardson.
1839. Birmingham	Prof. Owen, F.R.S.	E. Forbes, W. Ick, R. Patterson.
1840. Glasgow ...	Sir W. J. Hooker, LL.D.......	Prof. W. Couper, E. Forbes, R. Patterson.
1841. Plymouth...	John Richardson, M.D., F.R.S.	J. Couch, Dr. Lankester, R. Patterson.
1842. Manchester	Hon. and Very Rev. W. Herbert, LL.D., F.L.S.	Dr. Lankester, R. Patterson, J. A. Turner.

[1] At this Meeting Physiology and Anatomy were made a separate Committee, for Presidents and Secretaries of which see p. lxiii.

Date and Place	Presidents	Secretaries
1843. Cork.........	William Thompson, F.L.S....	G. J. Allman, Dr. Lankester, R. Patterson.
1844. York.........	Very Rev. the Dean of Manchester.	Prof. Allman, H. Goodsir, Dr. King, Dr. Lankester.
1845. Cambridge	Rev. Prof. Henslow, F.L.S....	Dr. Lankester, T. V. Wollaston.
1846. Southampton.	Sir J. Richardson, M.D., F.R.S.	Dr. Lankester, T. V. Wollaston, H. Wooldridge.
1847. Oxford......	H. E. Strickland, M.A., F.R.S.	Dr. Lankester, Dr. Melville, T. V. Wollaston.

SECTION D (*continued*).—ZOOLOGY AND BOTANY, INCLUDING PHYSIOLOGY.

[For the Presidents and Secretaries of the Anatomical and Physiological Subsections and the temporary Section E of Anatomy and Medicine, see p. lxiii.]

1848. Swansea ...	L. W. Dillwyn, F.R.S.........	Dr. R. Wilbraham Falconer, A. Henfrey, Dr. Lankester.
1849. Birmingham	William Spence, F.R.S.	Dr. Lankester, Dr. Russell.
1850. Edinburgh	Prof. Goodsir, F.R.S., F.R.S.E.	Prof. J. H. Bennett, M.D., Dr. Lankester, Dr. Douglas Maclagan.
1851. Ipswich ...	Rev. Prof. Henslow, M.A., F.R.S.	Prof. Allman, F. W. Johnston, Dr. E. Lankester.
1852. Belfast......	W. Ogilby	Dr. Dickie, George C. Hyndman, Dr. Edwin Lankester.
1853. Hull.........	C. C. Babington, M.A., F.R.S.	Robert Harrison, Dr. E. Lankester.
1854. Liverpool...	Prof. Balfour, M.D., F.R.S....	Isaac Byerley, Dr. E. Lankester.
1855. Glasgow ...	Rev. Dr. Fleeming, F.R.S.E.	William Keddie, Dr. Lankester.
1856. Cheltenham	Thomas Bell, F.R.S., Pres.L.S.	Dr. J. Abercrombie, Prof. Buckman, Dr. Lankester.
1857. Dublin......	Prof. W. H. Harvey, M.D., F.R.S.	Prof. J. R. Kinahan, Dr. E. Lankester, Robert Patterson, Dr. W. E. Steele.
1858. Leeds	C. C. Babington, M.A., F.R.S.	Henry Denny, Dr. Heaton, Dr. E. Lankester, Dr. E. Perceval Wright.
1859. Aberdeen...	Sir W. Jardine, Bart., F.R.S.E.	Prof. Dickie, M.D., Dr. E. Lankester, Dr. Ogilvy.
1860. Oxford......	Rev. Prof. Henslow, F.L.S....	W. S. Church, Dr. E. Lankester, P. L. Sclater, Dr. E. Perceval Wright.
1861. Manchester	Prof. C. C. Babington, F.R.S.	Dr. T. Alcock, Dr. E. Lankester, Dr. P. L. Sclater, Dr. E. P. Wright.
1862. Cambridge	Prof. Huxley, F.R.S.	Alfred Newton, Dr. E. P. Wright.
1863. Newcastle	Prof. Balfour, M.D., F.R.S....	Dr. E. Charlton, A. Newton, Rev. H. B. Tristram, Dr. E. P. Wright.
1864. Bath.........	Dr. John E. Gray, F.R.S. ...	H. B. Brady, C. E. Broom, H. T. Stainton, Dr. E. P. Wright.
1865. Birmingham[1]	T. Thomson, M.D., F.R.S. ...	Dr. J. Anthony, Rev. C. Clarke, Rev. H. B. Tristram, Dr. E. P. Wright.

SECTION D (*continued*).—BIOLOGY.

1866. Nottingham	Prof. Huxley, F.R.S.—*Dep. of Physiol.*, Prof. Humphry, F.R.S.—*Dep. of Anthropol.*, A. R. Wallace.	Dr. J. Beddard, W. Felkin, Rev. H. B. Tristram, W. Turner, E. B. Tylor, Dr. E. P. Wright.
1867. Dundee ...	Prof. Sharpey, M.D., Sec. R.S. —*Dep. of Zool. and Bot.*, George Busk, M.D., F.R.S.	C. Spence Bate, Dr. S. Cobbold, Dr. M. Foster, H. T. Stainton, Rev. H. B. Tristram, Prof. W. Turner.
1868. Norwich ...	Rev. M. J. Berkeley, F.L.S. —*Dep. of Physiology*, W. H. Flower, F.R.S.	Dr. T. S. Cobbold, G. W. Firth, Dr. M. Foster, Prof. Lawson, H. T. Stainton, Rev. Dr. H. B. Tristram, Dr. E. P. Wright.

[1] The title of Section D was changed to Biology.

Date and Place	Presidents	Secretaries
1869. Exeter	George Busk, F.R.S., F.L.S. —*Dep. of Bot. and Zool.*, C. Spence Bate, F.R.S.— *Dep. of Ethno.*, E. B. Tylor.	Dr. T. S. Cobbold, Prof. M. Foster, E. Ray Lankester, Prof. Lawson, H. T. Stainton, Rev. H. B. Tristram.
1870. Liverpool...	Prof. G. Rolleston, M.A., M.D., F.R.S., F.L.S.—*Dep. of Anat. and Physiol.*, Prof. M. Foster, M.D., F.L.S.—*Dep. of Ethno.*, J. Evans, F.R.S.	Dr. T. S. Cobbold, Sebastian Evans, Prof. Lawson, Thos. J. Moore, H. T. Stainton, Rev. H. B. Tristram, C. Staniland Wake, E. Ray Lankester.
1871. Edinburgh.	Prof. Allen Thomson, M.D., F.R.S.—*Dep. of Bot. and Zool.*, Prof. Wyville Thomson, F.R.S.—*Dep. of Anthropol.*, Prof. W. Turner, M.D.	Dr. T. R. Fraser, Dr. Arthur Gamgee, E. Ray Lankester, Prof. Lawson, H. T. Stainton, C. Staniland Wake, Dr. W. Rutherford, Dr. Kelburne King.
1872. Brighton ...	Sir J. Lubbock, Bart., F.R.S.— *Dep. of Anat. and Physiol.*, Dr. Burdon Sanderson, F.R.S.—*Dep. of Anthropol.*, Col. A. Lane Fox, F.G.S.	Prof. Thiselton-Dyer, H. T. Stainton, Prof. Lawson, F. W. Rudler, J. H. Lamprey, Dr. Gamgee, E. Ray Lankester, Dr. Pye-Smith.
1873. Bradford ...	Prof. Allman, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. Rutherford, M.D.—*Dep. of Anthropol.*, Dr. Beddoe, F.R.S.	Prof. Thiselton-Dyer, Prof. Lawson, R. M'Lachlan, Dr. Pye-Smith, E. Ray Lankester, F. W. Rudler, J. H. Lamprey.
1874. Belfast......	Prof. Redfern, M.D.—*Dep. of Zool. and Bot.*, Dr. Hooker, C.B., Pres. R.S.—*Dep. of Anthrop.*, Sir W. R. Wilde, M.D.	W. T. Thiselton-Dyer, R. O. Cunningham, Dr. J. J. Charles, Dr. P. H. Pye-Smith, J. J. Murphy, F. W. Rudler.
1875. Bristol	P. L. Sclater, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. Cleland, F.R.S.—*Dep. of Anth.*, Prof. Rolleston, F.R.S.	E. R. Alston, Dr. McKendrick, Prof. W. R. M'Nab, Dr. Martyn, F. W. Rudler, Dr. P. H. Pye-Smith, Dr. W. Spencer.
1876. Glasgow ...	A. Russel Wallace, F.L.S.— *Dep. of Zool. and Bot.*, Prof. A. Newton, F.R.S.— *Dep. of Anat. and Physiol.*, Dr. J. G. McKendrick.	E. R. Alston, Hyde Clarke, Dr. Knox, Prof. W. R. M'Nab, Dr. Muirhead, Prof. Morrison Watson.
1877. Plymouth...	J. Gwyn Jeffreys, F.R.S.— *Dep. of Anat. and Physiol.*, Prof. Macalister.—*Dep. of Anthropol.*, F. Galton, F.R.S.	E. R. Alston, F. Brent, Dr. D. J. Cunningham, Dr. C. A. Hingston, Prof. W. R. M'Nab, J. B. Rowe, F. W. Rudler.
1878. Dublin	Prof. W. H. Flower, F.R.S.— *Dep. of Anthropol.*, Prof. Huxley, Sec. R.S.—*Dep. of Anat. and Physiol.*, R. McDonnell, M.D., F.R.S.	Dr. R. J. Harvey, Dr. T. Hayden, Prof. W. R. M'Nab, Prof. J. M. Purser, J. B. Rowe, F. W. Rudler.
1879. Sheffield ...	Prof. St. George Mivart, F.R.S.—*Dep. of Anthropol.*, E. B. Tylor, D.C.L., F.R.S. —*Dep. of Anat. and Physiol.*, Dr. Pye-Smith.	Arthur Jackson, Prof. W. R. M'Nab, J. B. Rowe, F. W. Rudler, Prof. Schäfer.
1880. Swansea ...	A. C. L. Günther, F.R.S.—*Dep. of Anat. & Physiol.*, F. M. Balfour, F.R.S.—*Dep. of Anthropol.*, F. W. Rudler.	G. W. Bloxam, John Priestley, Howard Saunders, Adam Sedgwick.
1881. York........	R. Owen, F.R.S.—*Dep. of Anthropol.*, Prof. W. H. Flower, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. J. S. Burdon Sanderson, F.R.S.	G. W. Bloxam, W. A. Forbes, Rev. W. C. Hey, Prof. W. R. M'Nab, W. North, John Priestley, Howard Saunders, H. E. Spencer.

Date and Place	Presidents	Secretaries
1882. Southampton.	Prof. A. Gamgee, M.D., F.R.S. — *Dep. of Zool. and Bot.*, Prof. M. A. Lawson, F.L.S. —*Dep. of Anthropol.*, Prof. W. Boyd Dawkins, F.R.S.	G. W. Bloxam, W. Heape, J. B. Nias, Howard Saunders, A. Sedgwick, T. W. Shore, jun.
1883. Southport[1]	Prof. E. Ray Lankester, M.A., F.R.S.—*Dep. of Anthropol.*, W. Pengelly, F.R.S.	G. W. Bloxam, Dr. G. J. Haslam, W. Heape, W. Hurst, Prof. A. M. Marshall, Howard Saunders, Dr. G. A. Woods.
1884. Montreal ...	Prof. H. N. Moseley, M.A., F.R.S.	Prof. W. Osler, Howard Saunders, A. Sedgwick, Prof. R. R. Wright.
1885. Aberdeen ...	Prof. W. C. M'Intosh, M.D., LL.D., F.R.S., F.R.S.E.	W. Heape, J. McGregor-Robertson, J. Duncan Matthews, Howard Saunders, H. Marshall Ward.
1886. Birmingham	W. Carruthers, Pres. L.S., F.R.S., F.G.S.	Prof. T. W. Bridge, W. Heape, Prof. W. Hillhouse, W. L. Sclater, Prof. H. Marshall Ward.
1887. Manchester	Prof. A. Newton, M.A., F.R.S., F.L.S., V.P.Z.S.	C. Bailey, F. E. Beddard, S. F. Harmer, W. Heape, W. L. Sclater, Prof. H. Marshall Ward.
1888. Bath	W. T. Thiselton-Dyer, C.M.G., F.R.S., F.L.S.	F. E. Beddard, S. F. Harmer, Prof. H. Marshall Ward, W. Gardiner, Prof. W. D. Halliburton.
1889. Newcastle-upon-Tyne	Prof. J. S. Burdon Sanderson, M.A., M.D., F.R.S.	C. Bailey, F. E. Beddard, S. F. Harmer, Prof. T. Oliver, Prof. H. Marshall Ward.
1890. Leeds	Prof. A. Milnes Marshall, M.A., M.D., D.Sc., F.R.S.	S. F. Harmer, Prof. W. A. Herdman, S. J. Hickson, F. W. Oliver, H. Wager, H. Marshall Ward.
1891. Cardiff	Francis Darwin, M.A., M.B., F.R.S., F.L.S.	F. E. Beddard, Prof. W. A. Herdman, Dr. S. J. Hickson, G. Murray, Prof. W. N. Parker, H. Wager.
1892. Edinburgh	Prof. W. Rutherford, M.D., F.R.S., F.R.S.E.	G. Brook, Prof. W. A. Herdman, G. Murray, W. Stirling, H. Wager.
1893. Nottingham[2]	Rev. Canon H. B. Tristram, M.A., LL.D., F.R.S.	G. C. Bourne, J. B. Farmer, Prof. W. A. Herdman, S. J. Hickson, W. B. Ransom, W. L. Sclater.
1894. Oxford[3] ...	Prof. I. Bayley Balfour, M.A., F.R.S.	W. W. Benham, Prof. J. B. Farmer, Prof. W. A. Herdman, Prof. S. J. Hickson, G. Murray, W. L. Sclater.

SECTION D (*continued*).—ZOOLOGY.

1895. Ipswich ...	Prof. W. A. Herdman, F.R.S.	G. C. Bourne, H. Brown, W. E. Hoyle, W. L. Sclater.
1896. Liverpool...	Prof. E. B. Poulton, F.R.S. ...	H. O. Forbes, W. Garstang, W. E. Hoyle.
1897. Toronto ...	Prof. L. C. Miall, F.R.S.	W. Garstang, W. E. Hoyle, Prof. E. E. Prince.
1898. Bristol	Prof. W. F. R. Weldon, F.R.S.	Prof. R. Boyce, W. Garstang, Dr. A. J. Harrison, W. E. Hoyle.
1899. Dover	Adam Sedgwick, F.R.S.	W. Garstang, J. Graham Kerr.
1900. Bradford ...	Dr. R. H. Traquair, F.R.S. ...	W. Garstang, J. G. Kerr, T. H. Taylor, Swale Vincent.
1901. Glasgow ...	Prof. J. Cossar Ewart, F.R.S.	J. G. Kerr, J. Rankin, J. Y. Simpson.

[1] Anthropology was made a separate Section, see p. lxx.
[2] Physiology was made a separate Section, see p. lxxi.
[3] The title of Section D was changed to Zoology.

Date and Place	Presidents	Secretaries
1902. Belfast......	Prof. G. B. Howes, F.R.S. ...	Prof. J. G. Kerr, R. Patterson, J. Y. Simpson.
1903. Southport	Prof. S. J. Hickson, F.R.S. ...	Dr. J. H. Ashworth, J. Barcroft, A. Quayle, Dr. J. Y. Simpson, Dr. H. W. M. Tims.
1904. Cambridge	William Bateson, F.R.S.	Dr. J. H. Ashworth, L. Doncaster, Prof. J. Y. Simpson, Dr. H. W. M. Tims.
1905. SouthAfrica	G. A. Boulenger, F.R.S. ...	Dr. Pakes, Dr. Purcell, Dr. H. W. M. Tims, Prof. J. Y. Simpson.

ANATOMICAL AND PHYSIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, V.—ANATOMY AND PHYSIOLOGY.

1833. Cambridge	Dr. J. Haviland..................	Dr. H. J. H. Bond, Mr. G. E. Paget.
1834. Edinburgh	Dr. Abercrombie	Dr. Roget, Dr. William Thomson.

SECTION E (UNTIL 1847).—ANATOMY AND MEDICINE.

1835. Dublin	Dr. J. C. Pritchard	Dr. Harrison, Dr. Hart.
1836. Bristol	Dr. P. M. Roget, F.R.S.	Dr. Symonds.
1837. Liverpool...	Prof. W. Clark, M.D.	Dr. J. Carson, jun., James Long, Dr. J. R. W. Vose.
1838. Newcastle	T. E. Headlam, M.D.	T. M. Greenhow, Dr. J. R. W. Vose.
1839. Birmingham	John Yelloly, M.D., F.R.S....	Dr. G. O. Rees, F. Ryland.
1840. Glasgow ...	James Watson, M.D.	Dr. J. Brown, Prof. Couper, Prof. Reid.

SECTION E.—PHYSIOLOGY.

1841. Plymouth...	P. M. Roget, M.D., Sec. R.S.	J. Butter, J. Fuge, R. S. Sargent.
1842. Manchester	Edward Holme, M.D., F.L.S.	Dr. Chaytor, Dr. R. S. Sargent.
1843. Cork	Sir James Pitcairn, M.D. ...	Dr. John Popham, Dr. R. S. Sargent.
1844. York	J. C. Pritchard, M.D.	I. Erichsen, Dr. R. S. Sargent.
1845. Cambridge	Prof. J. Haviland, M.D.	Dr. R. S. Sargent, Dr. Webster.
1846. Southampton.	Prof. Owen, M.D., F.R.S. ...	C. P. Keele, Dr. Laycock, Dr. Sargent.
1847. Oxford[1] ...	Prof. Ogle, M.D., F.R.S.	T. K. Chambers, W. P. Ormerod.

PHYSIOLOGICAL SUBSECTIONS OF SECTION D.

1850. Edinburgh	Prof. Bennett, M.D., F.R.S.E.	
1855. Glasgow ...	Prof. Allen Thomson, F.R.S.	Prof. J. H. Corbett, Dr. J. Struthers.
1857. Dublin......	Prof. R. Harrison, M.D.	Dr. R. D. Lyons, Prof. Redfern.
1858. Leeds	Sir B. Brodie, Bart., F.R.S.	C. G. Wheelhouse.
1859. Aberdeen...	Prof. Sharpey, M.D., Sec.R.S.	Prof. Bennett, Prof. Redfern.
1860. Oxford......	Prof. G. Rolleston, M.D., F.L.S.	Dr. R. M'Donnell, Dr. Edward Smith.
1861. Manchester	Dr. John Davy, F.R.S.	Dr. W. Roberts, Dr. Edward Smith.
1862. Cambridge	G. E. Paget, M.D................	G. F. Helm, Dr. Edward Smith.
1863. Newcastle	Prof. Rolleston, M.D., F.R.S.	Dr. D. Embleton, Dr. W. Turner.
1864. Bath.........	Dr. Edward Smith, F.R.S.	J. S. Bartrum, Dr. W. Turner.
1865. Birmingham[2]	Prof. Acland, M.D., LL.D., F.R.S.	Dr. A. Fleming, Dr. P. Heslop, Oliver Pembleton, Dr. W. Turner.

[1] Sections D and E were incorporated under the name of 'Section D—Zoology and Botany, including Physiology' (see p. lix). Section E, being then vacant, was assigned in 1851 to Geography.

[2] *Vide* note on page lix.

Date and Place	Presidents	Secretaries

GEOGRAPHICAL AND ETHNOLOGICAL SCIENCES.

[For Presidents and Secretaries for Geography previous to 1851, see Section C, p. lvii.]

ETHNOLOGICAL SUBSECTIONS OF SECTION D.

1846. Southampton	Dr. J. C. Pritchard	Dr. King.
1847. Oxford	Prof. H. H. Wilson, M.A. ...	Prof. Buckley.
1848. Swansea ...	....	G. Grant Francis.
1849. Birmingham	....	Dr. R. G. Latham.
1850. Edinburgh	Vice-Admiral Sir A. Malcolm	Daniel Wilson.

SECTION E.—GEOGRAPHY AND ETHNOLOGY.

1851. Ipswich ...	Sir R. I. Murchison, F.R.S., Pres. R.G.S.	R. Cull, Rev. J. W. Donaldson, Dr. Norton Shaw.
1852. Belfast......	Col. Chesney, R.A., D.C.L., F.R.S.	R. Cull, E. MacAdam, Dr. Norton Shaw.
1853. Hull	R. G. Latham, M.D., F.R.S.	R. Cull, Rev. H. W. Kemp, Dr. Norton Shaw.
1854. Liverpool...	Sir R. I. Murchison, D.C.L., F.R.S.	Richard Cull, Rev. H. Higgins, Dr. Ihne, Dr. Norton Shaw.
1855. Glasgow ...	Sir J. Richardson, M.D., F.R.S.	Dr. W. G. Blackie, R. Cull, Dr. Norton Shaw.
1856. Cheltenham	Col. Sir H. C. Rawlinson, K.C.B.	R. Cull, F. D. Hartland, W. H. Rumsey, Dr. Norton Shaw.
1857. Dublin......	Rev. Dr. J. Henthorn Todd, Pres.R.I.A.	R. Cull, S. Ferguson, Dr. R. R. Madden, Dr. Norton Shaw.
1858. Leeds	Sir R. I. Murchison, G.C.St.S., F.R.S.	R. Cull, F. Galton, P. O'Callaghan, Dr. Norton Shaw, T. Wright.
1859. Aberdeen...	Rear - Admiral Sir James Clerk Ross, D.C.L., F.R.S.	Richard Cull, Prof. Geddes, Dr. Norton Shaw.
1860. Oxford......	Sir R. I. Murchison, D.C.L., F.R.S.	Capt. Burrows, Dr. J. Hunt, Dr. C. Lemprière, Dr. Norton Shaw.
1861. Manchester	John Crawfurd, F.R.S..........	Dr. J. Hunt, J. Kingsley, Dr. Norton Shaw, W. Spottiswoode.
1862. Cambridge	Francis Galton, F.R.S..........	J. W. Clarke, Rev. J. Glover, Dr. Hunt, Dr. Norton Shaw, T. Wright.
1863. Newcastle	Sir R. I. Murchison, K.C.B., F.R.S.	C. Carter Blake, Hume Greenfield, C. R. Markham, R. S. Watson.
1864. Bath.........	Sir R. I. Murchison, K.C.B., F.R.S.	H. W. Bates, C. R. Markham, Capt. R. M. Murchison, T. Wright.
1865. Birmingham	Major-General Sir H. Rawlinson, M.P., K.C.B., F.R.S.	H. W. Bates, S. Evans, G. Jabet, C. R. Markham, Thomas Wright.
1866. Nottingham	Sir Charles Nicholson, Bart., LL.D.	H. W. Bates, Rev. E. T. Cusins, R. H. Major, Clements R. Markham, D. W. Nash, T. Wright.
1867. Dundee ...	Sir Samuel Baker, F.R.G.S.	H. W. Bates, Cyril Graham, C. R. Markham, S. J. Mackie, R. Sturrock.
1868. Norwich ...	Capt. G. H. Richards, R.N., F.R.S.	T. Baines, H. W. Bates, Clements R. Markham, T. Wright.

SECTION E (*continued*).—GEOGRAPHY.

1869. Exeter	Sir Bartle Frere, K.C.B., LL.D., F.R.G.S.	H. W. Bates, Clements R. Markham, J. H. Thomas.
1870. Liverpool...	Sir R. I. Murchison, Bt., K.C.B., LL.D., D.C.L., F.R.S., F.G.S.	H. W. Bates, David Buxton, Albert J. Mott, Clements R. Markham.

Date and Place	Presidents	Secretaries
1871. Edinburgh	Colonel Yule, C.B., F.R.G.S.	A. Buchan, A. Keith Johnston, Clements R. Markham, J. H. Thomas.
1872. Brighton ...	Francis Galton, F.R.S..........	H. W. Bates, A. Keith Johnston, Rev. J. Newton, J. H. Thomas.
1873. Bradford ...	Sir Rutherford Alcock, K.C.B.	H. W. Bates, A. Keith Johnston, Clements R. Markham.
1874. Belfast......	Major Wilson, R.E., F.R.S., F.R.G.S.	E. G. Ravenstein, E. C. Rye, J. H. Thomas.
1875. Bristol......	Lieut. - General Strachey, R.E., C.S.I., F.R.S., F.R.G.S.	H. W. Bates, E. C. Rye, F. F. Tuckett.
1876. Glasgow ...	Capt. Evans, C.B., F.R.S.......	H. W. Bates, E. C. Rye, R. O. Wood.
1877. Plymouth...	Adm. Sir E. Ommanney, C.B.	H. W. Bates, F. E. Fox, E. C. Rye.
1878. Dublin......	Prof. Sir C. Wyville Thomson, LL.D., F.R.S., F.R S.E.	John Coles, E. C. Rye.
1879. Sheffield ...	Clements R. Markham, C.B., F.R.S., Sec. R.G.S.	H. W. Bates, C. E. D. Black, E. C. Rye.
1880. Swansea ...	Lieut.-Gen. Sir J. H. Lefroy, C.B., K.C.M.G., R.A., F.R.S.	H. W. Bates, E. C. Rye.
1881. York.........	Sir J. D. Hooker, K.C.S.I., C.B., F.R.S.	J. W. Barry, H. W. Bates.
1882. Southampton.	Sir R. Temple, Bart., G.C.S.I., F.R.G.S.	E. G. Ravenstein, E. C. Rye.
1883. Southport	Lieut.-Col. H. H. Godwin-Austen, F.R.S.	John Coles, E. G. Ravenstein, E. C. Rye.
1884. Montreal ...	Gen. Sir J. H. Lefroy, C.B., K.C.M.G., F.R.S., V.P.R.G.S.	Rev. Abbé Laflamme, J.S. O'Halloran, E. G. Ravenstein, J. F. Torrance.
1885. Aberdeen...	Gen. J. T. Walker, C.B., R.E., LL.D., F.R.S.	J. S. Keltie, J. S. O'Halloran, E. G. Ravenstein, Rev. G. A. Smith.
1886. Birmingham	Maj.-Gen. Sir. F. J. Goldsmid, K.C.S.I., C.B., F.R.G.S.	F. T. S. Houghton, J. S. Keltie. E. G. Ravenstein.
1887. Manchester	Col. Sir C. Warren, R.E., G.C.M.G., F.R.S., F.R.G.S.	Rev. L. C. Casartelli, J. S. Keltie, H. J. Mackinder, E. G. Ravenstein.
1888. Bath.........	Col. Sir C. W. Wilson, R.E., K.C.B., F.R.S., F.R.G.S.	J. S. Keltie, H. J. Mackinder, E. G. Ravenstein.
1889. Newcastle-upon-Tyne	Col. Sir F. de Winton, K.C.M.G., C.B., F.R.G.S.	J. S. Keltie, H. J. Mackinder, R. Sulivan, A. Silva White.
1890. Leeds	Lieut.-Col. Sir R. Lambert Playfair, K.C.M.G., F.R.G.S.	A. Barker, John Coles, J. S. Keltie, A. Silva White.
1891. Cardiff	E. G. Ravenstein, F.R.G.S., F.S.S.	John Coles, J. S. Keltie, H. J. Mackinder, A. Silva White, Dr. Yeats.
1892. Edinburgh	Prof. J. Geikie, D.C.L., F.R.S., V.P.R.Scot.G.S.	J. G. Bartholomew, John Coles, J. S. Keltie, A. Silva White.
1893. Nottingham	H. Seebohm, Sec. R.S., F.L.S., F.Z.S.	Col. F. Bailey, John Coles, H. O. Forbes, Dr. H. R. Mill.
1894. Oxford......	Capt. W. J. L. Wharton, R.N., F.R.S.	John Coles, W. S. Dalgleish, H. N. Dickson, Dr. H. R. Mill.
1895. Ipswich ...	H. J. Mackinder, M.A., F.R.G.S.	John Coles, H. N. Dickson, Dr. H. R. Mill, W. A. Taylor.
1896. Liverpool...	Major L. Darwin, Sec. R.G.S.	Col. F. Bailey, H. N. Dickson, Dr. H. R. Mill, E. C. DuB. Phillips.
1897. Toronto ...	J. Scott Keltie, LL.D.	Col. F. Bailey, Capt. Deville, Dr. H. R. Mill, J. B. Tyrrell.
1898. Bristol......	Col. G. Earl Church, F.R.G.S.	H. N. Dickson, Dr. H. R. Mill, H. C. Trapnell.
1899. Dover	Sir John Murray, F.R.S.	H. N. Dickson, Dr. H. O. Forbes, Dr. H. R. Mill.
1900. Bradford ...	Sir George S. Robertson, K.C.S.I.	H. N. Dickson, E. Heawood, E. R. Wethey.
1901. Glasgow ...	Dr. H. R. Mill, F.R.G.S.	H. N. Dickson, E. Heawood, G. Sandeman, A. C. Turner.

Date and Place	Presidents	Secretaries
1902. Belfast ...	Sir T. H. Holdich, K.C.B. ...	G. G. Chisholm, E. Heawood, Dr. A. J. Herbertson, Dr. J. A. Lindsay.
1903. Southport	Capt. E. W. Creak, R.N., C.B., F.R.S.	E. Heawood, Dr. A. J. Herbertson, E. A. Reeves, Capt. J. C. Underwood.
1904. Cambridge	Douglas W. Freshfield.........	E. Heawood, Dr. A. J. Herbertson, H. Y. Oldham, E. A. Reeves.
1905. SouthAfrica	Adm. Sir W. J. L. Wharton, R.N., K.C.B., F.R.S.	A. H. Cornish-Bowden, F. Flowers, Dr. A. J. Herbertson, H. Y. Oldham.

STATISTICAL SCIENCE.

COMMITTEE OF SCIENCES, VI.—STATISTICS.

1833. Cambridge	Prof. Babbage, F.R.S.	J. E. Drinkwater.
1834. Edinburgh	Sir Charles Lemon, Bart.......	Dr. Cleland, C. Hope Maclean.

SECTION F.—STATISTICS.

1835. Dublin	Charles Babbage, F.R.S.	W. Greg, Prof. Longfield.
1836. Bristol	Sir Chas. Lemon, Bart., F.R.S.	Rev. J. E. Bromby, C. B. Fripp, James Heywood.
1837. Liverpool...	Rt. Hon. Lord Sandon	W. R. Greg, W. Langton, Dr. W. C. Tayler.
1838. Newcastle	Colonel Sykes, F.R.S.	W. Cargill, J. Heywood, W. R. Wood.
1839. Birmingham	Henry Hallam, F.R.S.	F. Clarke, R. W. Rawson, Dr. W. C. Tayler.
1840. Glasgow ...	Lord Sandon, M.P., F.R.S.	C. R. Baird, Prof. Ramsay, R. W. Rawson.
1841. Plymouth...	Lieut.-Col. Sykes, F.R.S.......	Rev. Dr. Byrth, Rev. R. Luney, R. W. Rawson.
1842. Manchester	G. W. Wood, M.P., F.L.S. ...	Rev. R. Luney, G. W. Ormerod, Dr. W. C. Tayler.
1843. Cork	Sir C. Lemon, Bart., M.P. ...	Dr. D. Bullen, Dr. W. Cooke Tayler.
1844. York.........	Lieut.-Col. Sykes, F.R.S., F.L.S.	J. Fletcher, J. Heywood, Dr. Laycock.
1845. Cambridge	Rt. Hon. the Earl Fitzwilliam	J. Fletcher, Dr. W. Cooke Tayler.
1846. Southampton.	G. R. Porter, F.R.S.	J. Fletcher, F. G. P. Neison, Dr. W. C. Tayler, Rev. T. L. Shapcott.
1847. Oxford	Travers Twiss, D.C.L., F.R.S.	Rev. W. H. Cox, J. J. Danson, F. G. P. Neison.
1848. Swansea ...	J. H. Vivian, M.P., F.R.S. ...	J. Fletcher, Capt. R. Shortrede.
1849 Birmingham	Rt. Hon. Lord Lyttelton......	Dr. Finch, Prof. Hancock, F. P. G. Neison.
1850. Edinburgh	Very Rev. Dr. John Lee, V.P.R.S.E.	Prof. Hancock, J. Fletcher, Dr. J. Stark.
1851. Ipswich ...	Sir John P. Boileau, Bart. ...	J. Fletcher, Prof. Hancock.
1852. Belfast......	His Grace the Archbishop of Dublin.	Prof. Hancock, Prof. Ingram, James MacAdam, jun.
1853. Hull	James Heywood, M.P., F.R.S.	Edward Cheshire, W. Newmarch.
1854. Liverpool...	Thomas Tooke, F.R.S.	E. Cheshire, J. T. Danson, Dr. W. H. Duncan, W. Newmarch.
1855. Glasgow ...	R. Monckton Milnes, M.P. ...	J. A. Campbell, E. Cheshire, W. Newmarch, Prof. R. H. Walsh.

SECTION F (*continued*).—ECONOMIC SCIENCE AND STATISTICS.

1856. Cheltenham	Rt. Hon. Lord Stanley, M.P.	Rev. C. H. Bromby, E. Cheshire, Dr. W. N. Hancock, W. Newmarch, W. M. Tartt.
1857. Dublin......	His Grace the Archbishop of Dublin, M.R.I.A.	Prof. Cairns, Dr. H. D. Hutton, W. Newmarch.

Date and Place	Presidents	Secretaries
1858. Leeds	Edward Baines	T. B. Baines, Prof. Cairns, S. Brown, Capt. Fishbourne, Dr. J. Strang.
1859. Aberdeen ...	Col. Sykes, M.P., F.R.S.	Prof. Cairns, Edmund Macrory, A. M. Smith, Dr. John Strang.
1860. Oxford	Nassau W. Senior, M.A.	Edmund Macrory, W. Newmarch, Prof. J. E. T. Rogers.
1861. Manchester	William Newmarch, F.R.S....	David Chadwick, Prof. R. C. Christie, E. Macrory, Prof. J. E. T. Rogers.
1862. Cambridge	Edwin Chadwick, C.B.	H. D. Macleod, Edmund Macrory.
1863. Newcastle .	William Tite, M.P., F.R.S. ...	T. Doubleday, Edmund Macrory, Frederick Purdy, James Potts.
1864. Bath	W. Farr, M.D., D.C.L., F.R.S.	E. Macrory, E. T. Payne, F. Purdy.
1865. Birmingham	Rt. Hon. Lord Stanley, LL.D., M.P.	G. J. D. Goodman, G. J. Johnston, E. Macrory.
1866. Nottingham	Prof. J. E. T. Rogers	R. Birkin, jun., Prof. Leone Levi, E. Macrory.
1867. Dundee	M. E. Grant-Duff, M.P.	Prof. Leone Levi, E. Macrory, A. J. Warden.
1868. Norwich	Samuel Brown	Rev. W. C. Davie, Prof. Leone Levi.
1869. Exeter	Rt. Hon. Sir Stafford H. Northcote, Bart., C.B., M.P.	E. Macrory, F. Purdy, C. T. D. Acland.
1870. Liverpool...	Prof. W. Stanley Jevons, M.A.	Chas. R. Dudley Baxter, E. Macrory, J. Miles Moss.
1871. Edinburgh	Rt. Hon. Lord Neaves	J. G. Fitch, James Meikle.
1872 Brighton ...	Prof. Henry Fawcett, M.P. ...	J. G. Fitch, Barclay Phillips.
1873. Bradford ...	Rt. Hon. W. E. Forster, M.P.	J. G. Fitch, Swire Smith.
1874. Belfast......	Lord O'Hagan	Prof. Donnell, F. P. Fellows, Hans MacMordie.
1875. Bristol	James Heywood, M.A., F.R.S., Pres. S.S.	F. P. Fellows, T. G. P. Hallett, E. Macrory.
1876. Glasgow ...	Sir George Campbell, K.C.S.I., M.P.	A. M'Neel Caird, T. G. P. Hallett, Dr. W. Neilson Hancock, Dr. W. Jack.
1877. Plymouth...	Rt. Hon. the Earl Fortescue	W. F. Collier, P. Hallett, J. T. Pim.
1878. Dublin	Prof. J. K. Ingram, LL.D. ...	W. J. Hancock, C. Molloy, J. T. Pim.
1879. Sheffield ...	G. Shaw Lefevre, M.P., Pres. S.S.	Prof. Adamson, R. E. Leader, C. Molloy.
1880. Swansea ...	G. W. Hastings, M.P.	N. A. Humphreys, C. Molloy.
1881. York.........	Rt. Hon. M. E. Grant-Duff, M.A., F.R.S.	C. Molloy, W. W. Morrell, J. F. Moss.
1882. Southampton.	Rt. Hon. G. Sclater-Booth, M.P., F.R.S.	G. Baden-Powell, Prof. H. S. Foxwell, A. Milnes, C. Molloy.
1883. Southport	R. H. Inglis Palgrave, F.R.S.	Rev. W. Cunningham, Prof. H. S. Foxwell, J. N. Keynes, C. Molloy.
1884. Montreal ...	Sir Richard Temple, Bart., G.C.S.I., C.I.E., F.R.G.S.	Prof. H. S. Foxwell, J. S. McLennan, Prof. J. Watson.
1885. Aberdeen...	Prof. H. Sidgwick, LL.D., Litt.D.	Rev. W. Cunningham, Prof. H. S. Foxwell, C. McCombie, J. F. Moss.
1886. Birmingham	J. B. Martin, M.A., F.S.S.	F. F. Barham, Rev. W. Cunningham Prof. H. S. Foxwell, J. F. Moss.
1887. Manchester	Robert Giffen, LL.D., V.P.S.S.	Rev. W. Cunningham, F. Y. Edgeworth, T. H. Elliott, C. Hughes, J. E. C. Munro, G. H. Sargant.
1888. Bath	Rt. Hon. Lord Bramwell, LL.D., F.R.S.	Prof. F. Y. Edgeworth, T. H. Elliott, H. S. Foxwell, L. L. F. R. Price.
1889. Newcastle-upon-Tyne	Prof. F. Y. Edgeworth, M.A., F.S.S.	Rev. Dr. Cunningham, T. H. Elliott, F. B. Jevons, L. L. F. R. Price.
1890. Leeds	Prof. A. Marshall, M.A., F.S.S.	W. A. Brigg, Rev. Dr. Cunningham, T. H. Elliott, Prof. J. E. C. Munro, L. L. F. R. Price.

Date and Place	Presidents	Secretaries
1891. Cardiff. ...	Prof. W. Cunningham, D.D., D.Sc., F S.S.	Prof. J. Brough, E. Cannan, Prof. E. C. K. Gonner, H. Ll. Smith, Prof. W. R. Sorley.
1892. Edinburgh	Hon. Sir C. W. Fremantle. K.C.B.	Prof. J. Brough, J. R. Findlay, Prof. E. C. K. Gonner, H. Higgs, L. L. F. R. Price.
1893. Nottingham	Prof. J. S. Nicholson, D.Sc., F.S.S.	Prof. E C. K. Gonner, H. de B. Gibbins, J. A. H. Green, H. Higgs, L. L. F. R. Price.
1894. Oxford......	Prof. C. F. Bastable, M.A., F.S.S.	E. Cannan, Prof. E. C. K. Gonner, W. A. S. Hewins, H. Higgs.
1895. Ipswich ...	L. L. Price, M.A.	E. Cannan, Prof. E. C. K. Gonner, H. Higgs.
1896. Liverpool...	Rt. Hon. L. Courtney, M.P....	E. Cannan, Prof. E. C. K. Gonner, W. A. S. Hewins, H. Higgs.
1897. Toronto ...	Prof. E. C. K. Gonner, M.A.	E. Cannan, H. Higgs, Prof. A. Shortt.
1898. Bristol... ..	J. Bonar, M.A., LL.D.	E. Cannan, Prof. A. W. Flux, H. Higgs, W. E. Tanner.
1899. Dover	H. Higgs, LL.B.	A. L. Bowley, E. Cannan, Prof. A. W. Flux, Rev. G. Sarson.
1900. Bradford ...	Major P. G. Craigie, V.P.S.S.	A. L. Bowley, E. Cannan, S. J. Chapman, F. Hooper.
1901. Glasgow ...	Sir R. Giffen, K.C.B., F.R.S.	W. W. Blackie, A. L. Bowley, E. Cannan, S. J. Chapman.
1902. Belfast ...	E. Cannan, M.A., LL.D. ...	A. L. Bowley, Prof. S. J Chapman, Dr. A. Duffin
1903. Southport	E. W. Brabrook, C.B.	A. L. Bowley, Prof. S. J. Chapman, Dr. B. W. Ginsburg, G. Lloyd.
1904. Cambridge	Prof. Wm. Smart, LL.D.	J. E. Bidwell, A. L. Bowley, Prof. S. J. Chapman, Dr. B. W. Ginsburg.
1905. SouthAfrica	Rev. W. Cunningham, D.D., D.Sc.	R. à Ababrelton, A. L. Bowley, Prof. H. E. S. Fremantle, H. O. Meredith.

SECTION G.—MECHANICAL SCIENCE.

1836. Bristol......	Davies Gilbert, D.C.L., F.R.S.	T. G. Bunt, G. T. Clark, W. West.
1837. Liverpool...	Rev. Dr. Robinson	Charles Vignoles, Thomas Webster.
1838. Newcastle	Charles Babbage, F.R.S.......	R. Hawthorn, C. Vignoles, T. Webster.
1839. Birmingham	Prof. Willis, F.R.S., and Robt. Stephenson.	W. Carpmael, William Hawkes, T. Webster.
1840. Glasgow	Sir John Robinson	J. Scott Russell, J. Thomson, J. Tod, C. Vignoles.
1841. Plymouth	John Taylor, F.R.S.	Henry Chatfield, Thomas Webster.
1842. Manchester	Rev. Prof. Willis, F.R.S.	J. F. Bateman, J. Scott Russell, J. Thomson, Charles Vignoles.
1843. Cork	Prof. J. Macneill, M.R.I.A....	James Thomson, Robert Mallet.
1844. York.........	John Taylor, F.R.S.	Charles Vignoles, Thomas Webster.
1845. Cambridge	George Rennie, F.R.S..........	Rev. W. T. Kingsley.
1846. Southampton	Rev. Prof. Willis, M.A., F.R.S.	William Betts, jun., Charles Manby.
1847. Oxford......	Rev. Prof. Walker, M.A., F.R.S.	J. Glynn, R. A. Le Mesurier.
1848. Swansea ...	Rev. Prof. Walker, M.A., F.R.S.	R. A. Le Mesurier, W. P. Struvé.
1849. Birmingham	Robt. Stephenson, M.P., F.R.S.	Charles Manby, W. P. Marshall.
1850. Edinburgh	Rev. R. Robinson	Dr. Lees, David Stephenson.
1851. Ipswich ...	William Cubitt, F.R.S..........	John Head, Charles Manby.
1852. Belfast......	John Walker, C.E., LL.D., F.R.S.	John F. Bateman, C. B. Hancock, Charles Manby, James Thomson.
1853. Hull.........	William Fairbairn, F.R.S.	J. Oldham, J. Thomson, W. S. Ward.
1854. Liverpool...	John Scott Russell, F.R.S. ...	J. Grantham, J. Oldham, J. Thomson.
1855. Glasgow ...	W. J. M. Rankine, F.R.S. ...	L. Hill, W. Ramsay, J. Thomson.

Date and Place	Presidents	Secretaries
1856. Cheltenham	George Rennie, F.R.S.	C. Atherton, B. Jones, H. M. Jeffery.
1857. Dublin......	Rt. Hon. the Earl of Rosse, F.R.S.	Prof. Downing, W.T. Doyne, A. Tate, James Thomson, Henry Wright.
1858. Leeds	William Fairbairn, F.R.S. ...	J. C. Dennis, J. Dixon, H. Wright.
1859. Aberdeen...	Rev. Prof. Willis, M.A., F.R.S.	R. Abernethy, P. Le Neve Foster, H. Wright.
1860. Oxford	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, Rev. F. Harrison, Henry Wright.
1861. Manchester	J. F. Bateman, C.E., F.R.S....	P. Le Neve Foster, John Robinson, H. Wright.
1862. Cambridge.	William Fairbairn, F.R.S.	W. M. Fawcett, P. Le Neve Foster.
1863. Newcastle .	Rev. Prof. Willis, M.A., F.R.S.	P. Le Neve Foster, P. Westmacott, J. F. Spencer.
1864. Bath	J. Hawkshaw, F.R.S.	P. Le Neve Foster, Robert Pitt.
1865. Birmingham	Sir W. G. Armstrong, LL.D., F.R.S.	P. Le Neve Foster, Henry Lea, W. P. Marshall, Walter May.
1866. Nottingham	Thomas Hawksley, V.P. Inst. C.E., F.G.S.	P. Le Neve Foster, J. F. Iselin, M. O. Tarbotton.
1867. Dundee......	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, John P. Smith, W. W. Urquhart.
1868. Norwich ...	G. P. Bidder, C.E., F.R.G.S.	P. Le Neve Foster, J. F. Iselin, C. Manby, W. Smith.
1869. Exeter	C. W. Siemens, F.R.S.........	P. Le Neve Foster, H. Bauerman.
1870. Liverpool...	Chas. B. Vignoles, C.E., F.R.S.	H. Bauerman, P. Le Neve Foster, T. King, J. N. Shoolbred.
1871. Edinburgh	Prof. Fleeming Jenkin, F.R.S.	H. Bauerman, A. Leslie, J. P. Smith.
1872. Brighton ...	F. J. Bramwell, C.E.	H. M. Brunel, P. Le Neve Foster, J. G. Gamble, J. N. Shoolbred.
1873. Bradford ...	W. H. Barlow, F.R.S.	C. Barlow, H. Bauerman. E. H. Carbutt, J. C. Hawkshaw, J. N. Shoolbred.
1874. Belfast	Prof. James Thomson, LL.D., C.E., F.R.S.E.	A. T. Atchison, J. N. Shoolbred, John Smyth, jun.
1875. Bristol	W. Froude, C.E., M.A., F.R.S.	W. R. Browne, H. M. Brunel, J. G. Gamble, J. N. Shoolbred.
1876. Glasgow ...	C. W. Merrifield, F.R.S.	W. Bottomley, jun., W. J. Millar, J. N. Shoolbred, J. P. Smith.
1877. Plymouth...	Edward Woods, C.E.	A. T. Atchison, Dr. Merrifield, J. N. Shoolbred.
1878. Dublin	Edward Easton, C.E.	A. T. Atchison, R. G. Symes, H. T. Wood.
1879. Sheffield ...	J. Robinson, Pres. Inst. Mech. Eng.	A. T. Atchison, Emerson Bainbridge, H. T. Wood.
1880. Swansea ...	J. Abernethy, F.R.S.E..........	A. T. Atchison, H. T. Wood.
1881. York.........	Sir W. G. Armstrong, C.B., LL.D., D.C.L., F.R.S.	A. T. Atchison, J. F. Stephenson, H. T. Wood.
1882. Southampton.	John Fowler, C.E., F.G.S. ...	A. T. Atchison, F. Churton, H. T. Wood.
1883. Southport .	J. Brunlees, Pres. Inst. C.E.	A. T. Atchison, E. Rigg, H. T. Wood.
1884. Montreal ...	Sir F. J. Bramwell, F.R.S., V.P. Inst. C.E.	A. T. Atchison, W. B. Dawson, J. Kennedy, H. T. Wood.
1885. Aberdeen...	B. Baker, M.Inst.C.E.	A. T. Atchison, F. G. Ogilvie, E. Rigg, J. N. Shoolbred.
1886. Birmingham	Sir J. N. Douglass, M.Inst. C.E.	C. W. Cooke, J. Kenward, W. B. Marshall, E. Rigg.
1887. Manchester	Prof. Osborne Reynolds, M.A., LL.D., F.R.S.	C. F. Budenberg, W. B. Marshall E. Rigg.
1888. Bath	W. H. Preece, F.R.S., M.Inst.C.E.	C. W. Cooke, W. B. Marshall, E. Rigg, P. K. Stothert.
1889. Newcastle-upon-Tyne	W. Anderson, M.Inst.C.E. ...	C. W. Cooke, W. B. Marshall, Hon C. A. Parsons, E. Rigg.

Date and Place	Presidents	Secretaries
1890. Leeds	Capt. A. Noble, C.B., F.R.S., F.R.A.S.	E. K. Clark, C. W. Cooke, W. B. Marshall, E. Rigg.
1891. Cardiff	T. Forster Brown, M.Inst.C.E.	C. W. Cooke, Prof. A. C. Elliott, W. B. Marshall, E. Rigg.
1892. Edinburgh	Prof. W. C. Unwin, F.R.S., M.Inst.C.E.	C. W. Cooke, W. B. Marshall, W. C. Popplewell, E. Rigg.
1893. Nottingham	Jeremiah Head, M.Inst C.E., F.C.S.	C. W. Cooke, W. B. Marshall, E. Rigg, H. Talbot.
1894. Oxford	Prof. A. B. W. Kennedy, F.R.S., M.Inst.C.E.	Prof. T. Hudson Beare, C. W. Cooke, W. B. Marshall, Rev. F. J. Smith.
1895. Ipswich ...	Prof. L. F. Vernon-Harcourt, M.A., M.Inst.C.E.	Prof. T. Hudson Beare, C. W. Cooke, W. B. Marshall, P. G. M. Stoney.
1896. Liverpool...	Sir Douglas Fox, V.P.Inst.C.E.	Prof. T. Hudson Beare, C. W. Cooke, S. Dunkerley, W. B. Marshall.
1897. Toronto ...	G. F. Deacon, M.Inst.C.E.	Prof. T. Hudson Beare, Prof. Callendar, W. A. Price.
1898. Bristol	Sir J. Wolfe-Barry, K.C.B., F.R.S.	Prof. T. H. Beare, Prof. J. Munro, H. W. Pearson, W. A. Price.
1899. Dover	Sir W. White, K.C.B., F.R.S.	Prof. T. H. Beare, W. A. Price, H. E. Stilgoe.
1900. Bradford [1]	Sir Alex. R. Binnie, M.Inst. C.E.	Prof. T. H. Beare, C. F. Charnock, Prof. S. Dunkerley, W. A. Price.

SECTION G.—ENGINEERING.

1901. Glasgow ...	R. E. Crompton, M.Inst.C.E.	H. Bamford, W.E. Dalby, W. A. Price.
1902. Belfast ...	Prof. J. Perry, F.R.S.	M. Barr, W. A. Price, J. Wylie.
1903. Southport	C. Hawksley, M.Inst.C.E. ...	Prof. W. E. Dalby, W. T. Maccall, W. A. Price.
1904. Cambridge	Hon. C. A. Parsons, F.R.S. ...	J. B. Peace, W. T. Maccall, W. A. Price.
1905. SouthAfrica	Col. Sir C. Scott-Moncrieff, G.C.S.I., K.C.M.G., R.E.	W. T. Maccall, W. B. Marshall, Prof. H. Payne, E. Williams.

SECTION H.—ANTHROPOLOGY.

1884. Montreal ...	E. B. Tylor, D.C.L., F.R.S. ...	G. W. Bloxam, W. Hurst.
1885. Aberdeen...	Francis Galton, M.A., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, W. Hurst, Dr. A. Macgregor.
1886. Birmingham	Sir G. Campbell, K.C.S.I., M.P., D.C.L., F.R.G.S.	G. W. Bloxam, Dr. J. G. Garson, W. Hurst, Dr. R. Saundby.
1887. Manchester	Prof. A. H. Sayce, M.A.	G. W. Bloxam, Dr. J. G. Garson, Dr. A. M. Paterson.
1888. Bath	Lieut.-General Pitt-Rivers, D.C.L., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, J. Harris Stone.
1889. Newcastle-upon-Tyne	Prof. Sir W. Turner, M.B., LL.D., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, Dr. R. Morison, Dr. R. Howden.
1890. Leeds	Dr. J. Evans, Treas. R.S., F.S.A., F.L.S., F.G.S.	G. W. Bloxam, Dr. C. M. Chadwick, Dr. J. G. Garson.
1891. Cardiff	Prof. F. Max Müller, M.A. ...	G. W. Bloxam, Prof. R. Howden, H. Ling Roth, E. Seward.
1892. Edinburgh	Prof. A. Macalister, M.A., M.D., F.R.S.	G. W. Bloxam, Dr. D. Hepburn, Prof. R. Howden, H. Ling Roth.
1893. Nottingham	Dr. R. Munro, M.A., F.R.S.E.	G. W. Bloxam, Rev. T. W. Davies, Prof. R. Howden, F. B. Jevons, J. L. Myres.
1894. Oxford	Sir W. H. Flower, K.C.B., F.R.S.	H. Balfour, Dr. J. G. Garson, H. Ling Roth.
1895. Ipswich ...	Prof. W. M. Flinders Petrie, D.C.L.	J. L. Myres, Rev. J. J. Raven, H. Ling Roth.

[1] The title of Section G was changed to Engineering.

Date and Place	Presidents	Secretaries
1896. Liverpool...	Arthur J. Evans, F.S.A.	Prof. A. C. Haddon, J. L. Myres, Prof. A. M. Paterson.
1897. Toronto ...	Sir W. Turner, F.R.S.	A. F. Chamberlain, H. O. Forbes, Prof. A. C. Haddon, J. L. Myres.
1898. Bristol	E. W. Brabrook, C.B.	H. Balfour, J. L. Myres, G. Parker.
1899. Dover	C. H. Read, F.S.A.	H. Balfour, W. H. East, Prof. A. C. Haddon, J. L. Myres.
1900. Bradford ...	Prof. John Rhys, M.A.........	Rev. E. Armitage, H. Balfour, W. Crooke, J. L. Myres.
1901. Glasgow ...	Prof. D. J. Cunningham, F.R.S.	W. Crooke, Prof. A. F. Dixon, J. F. Gemmill, J. L. Myres.
1902. Belfast ...	Dr. A. C. Haddon, F.R.S. ...	R. Campbell, Prof. A. F. Dixon, J. L. Myres.
1903. Southport	Prof. J. Symington, F.R.S. ...	E. N. Fallaize, H. S. Kingsford, E. M. Littler, J. L. Myres.
1904. Cambridge	H. Balfour, M.A.	W. L. H. Duckworth, E. N. Fallaize, H. S. Kingsford, J. L. Myres.
1905. SouthAfrica	Dr. A. C. Haddon, F.R.S. ...	A. R. Brown, A. von Dessauer, E. S. Hartland.

SECTION I.—PHYSIOLOGY (including Experimental Pathology and Experimental Psychology).

Date and Place	Presidents	Secretaries
1894. Oxford.. ...	Prof. E. A. Schäfer, F.R.S., M.R.C.S.	Prof. F. Gotch, Dr. J. S. Haldane, M. S. Pembrey.
1896. Liverpool ..	Dr. W. H. Gaskell, F.R.S.	Prof. R. Boyce, Prof. C. S. Sherrington.
1897. Toronto ...	Prof. Michael Foster, F.R.S.	Prof. R. Boyce, Prof. C. S. Sherrington, Dr. L. E. Shore.
1899. Dover	J. N. Langley, F.R.S.	Dr. Howden, Dr. L. E. Shore, Dr. E. H. Starling.
1901. Glasgow ...	Prof. J. G. McKendrick, F.R.S.	W. B. Brodie, W. A. Osborne, Prof. W. H. Thompson.
1902. Belfast ...	Prof. W. D. Halliburton, F.R.S.	J. Barcroft, Dr. W. A. Osborne, Dr. C. Shaw.
1904. Cambridge	Prof. C. S. Sherrington, F.R.S.	J. Barcroft, Prof. T. G. Brodie, Dr. L. E. Shore.
1905. SouthAfrica	Col. D. Bruce, C.B., F.R.S. ...	J. Barcroft, Dr. Baumann, Dr. Mackenzie, Dr. G. W. Robertson, Dr. Stanwell.

SECTION K.—BOTANY.

Date and Place	Presidents	Secretaries
1895. Ipswich ...	W. T. Thiselton-Dyer, F.R.S.	A. C. Seward, Prof. F. E. Weiss.
1896. Liverpool...	Dr. D. H. Scott, F.R.S.	Prof. Harvey Gibson, A. C. Seward, Prof. F. E. Weiss.
1897. Toronto ...	Prof. Marshall Ward, F.R.S.	Prof. J. B. Farmer, E. C. Jeffrey, A. C. Seward, Prof. F. E. Weiss.
1898. Bristol	Prof. F. O. Bower, F.R.S. ...	A. C. Seward, H. Wager, J. W. White.
1899. Dover	Sir George King, F.R.S.	G. Dowker, A. C. Seward, H. Wager.
1900. Bradford ...	Prof. S. H. Vines, F.R.S.	A. C. Seward, H. Wager, W. West.
1901. Glasgow ...	Prof. I. B. Balfour, F.R.S. ...	D. T. Gwynne-Vaughan, G. F. Scott-Elliot, A. C. Seward, H. Wager.
1902. Belfast ...	Prof. J. R. Green, F.R.S.	A. G. Tansley, Rev. C. H. Waddell, H. Wager, R. H. Yapp.
1903. Southport	A. C. Seward, F.R.S.	H. Ball, A. G. Tansley, H. Wager, R. H. Yapp.
1904. Cambridge	Francis Darwin, F.R.S.	Dr. F. F. Blackman, A. G. Tansley, H. Wager, T. B. Wood, R. H. Yapp.
1905. SouthAfrica	Harold Wager, F.R.S. ...	R. P. Gregory, Dr. Marloth, Prof. Pearson, Prof. R. H. Yapp.

SECTION L.—EDUCATIONAL SCIENCE.

Date and Place	Presidents	Secretaries
1901. Glasgow ...	Sir John E. Gorst, F.R.S. ...	R. A. Gregory, W. M. Heller, R. Y. Howie, C. W. Kimmins, Prof. H. L. Withers.
1902. Belfast ...	Prof. H. E. Armstrong, F.R.S.	Prof. R. A. Gregory, W. M. Heller, R. M. Jones, Dr. C. W. Kimmins, Prof. H. L. Withers.
1903. Southport	Sir W. de W. Abney, K.C.B., F.R.S.	Prof. R. A. Gregory, W. M. Heller, Dr. C. W. Kimmins, Dr. H. L. Snape.
1904. Cambridge	Bishop of Hereford, D.D. ...	J. H. Flather, Prof. R. A. Gregory, W. M. Heller, Dr. C. W. Kimmins.
1905. SouthAfrica	Prof. Sir R. C. Jebb, D.C.L., M.P.	A. D. Hall, Prof. Hele-Shaw, Dr. C. W. Kimmins, J. R. Whitton.

LIST OF EVENING DISCOURSES.

Date and Place	Lecturer	Subject of Discourse
1842. Manchester	Charles Vignoles, F.R.S......	The Principles and Construction of Atmospheric Railways.
	Sir M. I. Brunel	The Thames Tunnel.
	R. I. Murchison..................	The Geology of Russia.
1843. Cork	Prof. Owen, M.D., F.R.S.......	The Dinornis of New Zealand.
	Prof. E. Forbes, F.R.S..........	The Distribution of Animal Life in the Ægean Sea.
	Dr Robinson	The Earl of Rosse's Telescope.
1844. York	Charles Lyell, F.R.S.	Geology of North America.
	Dr. Falconer, F.R.S.............	The Gigantic Tortoise of the Siwalik Hills in India.
1845. Cambridge	G.B.Airy,F.R.S.,Astron.Royal	Progress of Terrestrial Magnetism.
	R. I. Murchison, F.R.S.	Geology of Russia.
1846. Southampton.	Prof. Owen, M.D., F.R.S. ...	Fossil Mammalia of the British Isles.
	Charles Lyell, F.R.S.	Valley and Delta of the Mississippi.
	W. R. Grove, F.R.S.	Properties of the Explosive Substance discovered by Dr. Schönbein; also some Researches of his own on the Decomposition of Water by Heat.
1847. Oxford......	Rev. Prof. B. Powell, F.R.S.	Shooting Stars.
	Prof. M. Faraday, F.R.S.......	Magnetic and Diamagnetic Phenomena.
	Hugh E. Strickland, F.G.S....	The Dodo (*Didus ineptus*).
1848. Swansea ...	John Percy, M.D., F.R.S.......	Metallurgical Operations of Swansea and its Neighbourhood.
	W. Carpenter, M.D., F.R.S....	Recent Microscopical Discoveries.
1849. Birmingham	Dr. Faraday, F.R.S.	Mr. Gassiot's Battery.
	Rev. Prof. Willis, M.A., F.R.S.	Transit of different Weights with varying Velocities on Railways.
1850. Edinburgh	Prof. J. H. Bennett, M.D., F.R.S.E.	Passage of the Blood through the minute vessels of Animals in connection with Nutrition.
	Dr. Mantell, F.R.S.	Extinct Birds of New Zealand.
1851. Ipswich ...	Prof. R. Owen, M.D., F.R.S.	Distinction between Plants and Animals, and their changes of Form.

Date and Place	Lecturer	Subject of Discourse
1851. Ipswich ...	G. B. Airy, F.R.S., Astronomer Royal	Total Solar Eclipse of July 28, 1851.
1852. Belfast......	Prof. G. G. Stokes, D.C.L., F.R.S.	Recent Discoveries in the properties of Light.
	Colonel Portlock, R.E., F.R.S.	Recent Discovery of Rock-salt at Carrickfergus, and geological and practical considerations connected with it.
1853. Hull.........	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	Some peculiar Phenomena in the Geology and Physical Geography of Yorkshire.
	Robert Hunt, F.R.S.............	The present state of Photography.
1854. Liverpool...	Prof. R. Owen, M.D., F.R.S.	Anthropomorphous Apes.
	Col. E. Sabine, V.P.R.S.	Progress of Researches in Terrestrial Magnetism.
1855. Glasgow ...	Dr. W. B. Carpenter, F.R.S.	Characters of Species.
	Lieut.-Col. H. Rawlinson ...	Assyrian and Babylonian Antiquities and Ethnology.
1856. Cheltenham	Col. Sir H. Rawlinson	Recent Discoveries in Assyria and Babylonia, with the results of Cuneiform Research up to the present time.
	W. R. Grove, F.R.S.............	Correlation of Physical Forces.
1857. Dublin......	Prof. W. Thomson, F.R.S. ...	The Atlantic Telegraph.
	Rev. Dr. Livingstone, D.C.L.	Recent Discoveries in Africa.
1858. Leeds	Prof. J. Phillips, LL.D., F.R.S.	The Ironstones of Yorkshire.
	Prof. R. Owen, M.D., F.R.S.	The Fossil Mammalia of Australia.
1859. Aberdeen...	Sir R. I. Murchison, D.C.L....	Geology of the Northern Highlands.
	Rev. Dr. Robinson, F.R.S. ...	Electrical Discharges in highly rarefied Media.
1860. Oxford......	Rev. Prof. Walker, F.R.S. ...	Physical Constitution of the Sun.
	Captain Sherard Osborn, R.N.	Arctic Discovery.
1861. Manchester	Prof. W. A. Miller, M.A., F.R.S.	Spectrum Analysis.
	G. B. Airy, F.R.S., Astron. Royal	The late Eclipse of the Sun.
1862. Cambridge	Prof. Tyndall, LL.D., F.R.S.	The Forms and Action of Water.
	Prof. Odling, F.R.S.............	Organic Chemistry.
1863. Newcastle	Prof. Williamson, F.R.S.......	The Chemistry of the Galvanic Battery considered in relation to Dynamics.
	James Glaisher, F.R.S.........	The Balloon Ascents made for the British Association.
1864. Bath.........	Prof. Roscoe, F.R.S............	The Chemical Action of Light.
	Dr. Livingstone, F.R.S.	Recent Travels in Africa.
1865. Birmingham	J. Beete Jukes, F.R.S.........	Probabilities as to the position and extent of the Coal-measures beneath the red rocks of the Midland Counties.
1866. Nottingham	William Huggins, F.R.S.......	The results of Spectrum Analysis applied to Heavenly Bodies.
	Dr. J. D. Hooker, F.R.S.......	Insular Floras.
1867. Dundee......	Archibald Geikie, F.R.S.......	The Geological Origin of the present Scenery of Scotland.
	Alexander Herschel, F.R.A.S.	The present state of Knowledge regarding Meteors and Meteorites.
1868. Norwich ...	J. Fergusson, F.R.S............	Archæology of the early Buddhist Monuments.
	Dr. W. Odling, F.R.S.	Reverse Chemical Actions.
1869. Exeter	Prof. J. Phillips, LL.D., F.R.S.	Vesuvius.
	J. Norman Lockyer, F.R.S. ...	The Physical Constitution of the Stars and Nebulæ.

Date and Place	Lecturer	Subject of Discourse
1870. Liverpool...	Prof. J. Tyndall, LL.D., F.R.S.	The Scientific Use of the Imagination.
	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	Stream-lines and Waves, in connection with Naval Architecture.
1871. Edinburgh	F. A. Abel, F.R.S.............	Some Recent Investigations and Applications of Explosive Agents.
	E. B. Tylor, F.R.S.	The Relation of Primitive to Modern Civilisation.
1872. Brighton ...	Prof. P. Martin Duncan, M.B., F.R.S.	Insect Metamorphosis.
	Prof. W. K. Clifford	The Aims and Instruments of Scientific Thought.
1873. Bradford ...	Prof. W. C. Williamson, F.R.S.	Coal and Coal Plants.
	Prof. Clerk Maxwell, F.R.S.	Molecules.
1874. Belfast	Sir John Lubbock, Bart., M.P., F.R.S.	Common Wild Flowers considered in relation to Insects.
	Prof. Huxley, F.R.S.	The Hypothesis that Animals are Automata, and its History.
1875. Bristol	W. Spottiswoode, LL.D., F.R.S.	The Colours of Polarised Light.
	F. J. Bramwell, F.R.S..........	Railway Safety Appliances.
1876. Glasgow ...	Prof. Tait, F.R.S.E.	Force.
	Sir Wyville Thomson, F.R.S.	The 'Challenger' Expedition.
1877. Plymouth...	W. Warington Smyth, M.A., F.R.S.	Physical Phenomena connected with the Mines of Cornwall and Devon.
	Prof. Odling, F.R.S.............	The New Element, Gallium.
1878. Dublin	G. J. Romanes, F.L.S.	Animal Intelligence.
	Prof. Dewar, F.R.S.	Dissociation, or Modern Ideas of Chemical Action.
1879. Sheffield ...	W. Crookes, F.R.S.	Radiant Matter.
	Prof. E. Ray Lankester, F.R.S.	Degeneration.
1880. Swansea ...	Prof. W. Boyd Dawkins, F.R.S.	Primeval Man.
	Francis Galton, F.R.S..........	Mental Imagery.
1881. York.........	Prof. Huxley, Sec. R.S.	The Rise and Progress of Palæontology.
	W. Spottiswoode, Pres. R.S....	The Electric Discharge, its Forms and its Functions.
1882. Southampton.	Prof. Sir Wm. Thomson, F.R.S.	Tides.
	Prof. H. N. Moseley, F.R.S.	Pelagic Life.
1883. Southport	Prof. R. S. Ball, F.R.S.	Recent Researches on the Distance of the Sun.
	Prof. J. G. McKendrick.	Galvanic and Animal Electricity.
1884. Montreal ...	Prof. O. J. Lodge, D.Sc.	Dust.
	Rev. W. H. Dallinger, F.R.S.	The Modern Microscope in Researches on the Least and Lowest Forms of Life.
1885. Aberdeen...	Prof. W. G. Adams, F.R.S. ...	The Electric Light and Atmospheric Absorption.
	John Murray, F.R.S.E.........	The Great Ocean Basins.
1886. Birmingham	A. W. Rücker, M.A., F.R.S.	Soap Bubbles.
	Prof. W. Rutherford, M.D. ...	The Sense of Hearing.
1887. Manchester	Prof. H. B. Dixon, F.R.S. ...	The Rate of Explosions in Gases.
	Col. Sir F. de Winton	Explorations in Central Africa.
1888. Bath	Prof. W. E. Ayrton, F.R.S. ...	The Electrical Transmission of Power.
	Prof. T. G. Bonney, D.Sc., F.R.S.	The Foundation Stones of the Earth's Crust.
1889. Newcastle-upon-Tyne	Prof. W. C. Roberts-Austen, F.R.S.	The Hardening and Tempering of Steel.
	Walter Gardiner, M.A.........	How Plants maintain themselves in the Struggle for Existence.
1890. Leeds	E. B. Poulton, M.A., F.R.S....	Mimicry.
	Prof. C. Vernon Boys, F.R.S.	Quartz Fibres and their Applications.

Date and Place	Lecturer	Subject of Discourse
1891. Cardiff	Prof. L. C. Miall, F.L.S., F.G.S.	Some Difficulties in the Life of Aquatic Insects.
	Prof. A. W. Rücker, M.A., F.R.S.	Electrical Stress.
1892. Edinburgh	Prof. A. M. Marshall, F.R.S.	Pedigrees.
	Prof. J. A. Ewing, M.A., F.R.S.	Magnetic Induction.
1893. Nottingham	Prof. A. Smithells, B.Sc.	Flame.
	Prof. Victor Horsley, F.R.S.	The Discovery of the Physiology of the Nervous System.
1894. Oxford	J. W. Gregory, D.Sc., F.G.S.	Experiences and Prospects of African Exploration.
	Prof. J. Shield Nicholson, M.A.	Historical Progress and Ideal Socialism.
1895. Ipswich ...	Prof. S. P. Thompson, F.R.S.	Magnetism in Rotation.
	Prof. Percy F. Frankland, F.R.S.	The Work of Pasteur and its various Developments.
1896. Liverpool...	Dr. F. Elgar, F.R.S.	Safety in Ships.
	Prof. Flinders Petrie, D.C.L.	Man before Writing.
1897. Toronto ...	Prof. W. C. Roberts-Austen, F.R.S.	Canada's Metals.
	J. Milne, F.R.S..................	Earthquakes and Volcanoes.
1898. Bristol	Prof. W. J. Sollas, F.R.S. ..	Funafuti: the Study of a Coral Island.
	Herbert Jackson	Phosphorescence.
1899. Dover	Prof. Charles Richet...........	La vibration nerveuse.
	Prof. J. Fleming, F.R.S.	The Centenary of the Electric Current.
1900. Bradford ...	Prof. F. Gotch, F.R.S.	Animal Electricity.
	Prof. W. Stroud.	Range Finders.
1901. Glasgow ...	Prof. W. Ramsay, F.R.S.	The Inert Constituents of the Atmosphere.
	F. Darwin, F.R.S.	The Movements of Plants.
1902. Belfast ...	Prof. J. J. Thomson, F.R.S....	Becquerel Rays and Radio-activity.
	Prof. W. F. R. Weldon, F.R.S.	Inheritance.
1903. Southport	Dr. R. Munro	Man as Artist and Sportsman in the Palæolithic Period.
	Dr. A. Rowe	The Old Chalk Sea, and some of its Teachings.
1904. Cambridge	Prof. G. H. Darwin, F.R.S....	Ripple-Marks and Sand-Dunes.
	Prof. H. F. Osborn	Palæontological Discoveries in the Rocky Mountains.
1905. South Africa:		
Cape Town ...	Prof. E. B. Poulton, F.R.S. ...	W. J. Burchell's Discoveries in South Africa.
	C. Vernon Boys, F.R.S. ...	Some Surface Actions of Fluids.
Durban ...	Douglas W. Freshfield ...	The Mountains of the Old World.
	Prof. W. A. Herdman, F.R.S.	Marine Biology.
Pietermaritzburg	Col. D. Bruce, C.B., F.R.S....	Sleeping Sickness.
	H. T. Ferrar	The Cruise of the 'Discovery.'
Johannesburg	Prof. W. E. Ayrton, F.R.S ...	The Distribution of Power.
	Prof. J. O. Arnold	Steel as an Igneous Rock.
Pretoria ...	A. E. Shipley, F.R.S. ...	Flyborne Diseases: Malaria, Sleeping Sickness, &c.
Bloemfontein...	A. R. Hinks	The Milky Way and the Clouds of Magellan.
Kimberley ...	Sir Wm. Crookes, F.R.S. ...	Diamonds.
	Prof. J. B. Porter	The Bearing of Engineering on Mining.
Bulawayo ...	D. Randall-MacIver	The Ruins of Rhodesia.

LECTURES TO THE OPERATIVE CLASSES.

Date and Place	Lecturer	Subject of Lecture
1867. Dundee......	Prof. J. Tyndall, LL.D., F.R.S.	Matter and Force.
1868. Norwich ...	Prof. Huxley, LL.D., F.R.S.	A Piece of Chalk.
1869. Exeter	Prof. Miller, M.D., F.R.S. ...	The modes of detecting the Composition of the Sun and other Heavenly Bodies by the Spectrum.
1870. Liverpool...	Sir John Lubbock, Bart., F.R.S.	Savages.
1872. Brighton ...	W. Spottiswoode, LL.D., F.R.S.	Sunshine, Sea, and Sky.
1873. Bradford ...	C. W. Siemens, D.C.L., F.R.S.	Fuel.
1874. Belfast	Prof. Odling, F.R.S.............	The Discovery of Oxygen.
1875. Bristol	Dr. W. B. Carpenter, F.R.S.	A Piece of Limestone.
1876. Glasgow ...	Commander Cameron, C.B....	A Journey through Africa.
1877. Plymouth...	W. H. Preece.....................	Telegraphy and the Telephone.
1879. Sheffield ...	W. E. Ayrton	Electricity as a Motive Power.
1880. Swansea ...	H. Seebohm, F.Z.S.	The North-East Passage.
1881. York	Prof. Osborne Reynolds, F.R.S.	Raindrops, Hailstones, and Snowflakes.
1882. Southampton.	John Evans, D.C.L., Treas. R.S.	Unwritten History, and how to read it.
1883. Southport	Sir F. J. Bramwell, F.R.S. ...	Talking by Electricity—Telephones.
1884. Montreal ...	Prof. R. S. Ball, F.R.S.........	Comets.
1885. Aberdeen ...	H. B. Dixon, M.A.	The Nature of Explosions.
1886. Birmingham	Prof. W. C. Roberts-Austen, F.R.S.	The Colours of Metals and their Alloys.
1887. Manchester	Prof. G. Forbes, F.R.S.	Electric Lighting.
1888. Bath.........	Sir John Lubbock, Bart., F.R.S.	The Customs of Savage Races.
1889. Newcastle-upon-Tyne	B. Baker, M.Inst.C.E.	The Forth Bridge.
1890. Leeds	Prof. J. Perry, D.Sc., F.R.S.	Spinning Tops.
1891. Cardiff	Prof. S. P. Thompson, F.R.S.	Electricity in Mining.
1892. Edinburgh	Prof. C. Vernon Boys, F.R.S.	Electric Spark Photographs.
1893. Nottingham	Prof. Vivian B. Lewes	Spontaneous Combustion.
1894. Oxford	Prof. W. J. Sollas, F.R.S. ...	Geologies and Deluges.
1895. Ipswich ...	Dr. A. H. Fison.................	Colour.
1896. Liverpool...	Prof. J. A. Fleming, F.R.S....	The Earth a Great Magnet.
1897. Toronto ...	Dr. H. O. Forbes	New Guinea.
1898. Bristol	Prof. E. B. Poulton, F.R.S. ...	The ways in which Animals Warn their enemies and Signal to their friends.
1900. Bradford ...	Prof. S. P. Thompson, F.R.S.	Electricity in the Industries.
1901. Glasgow ...	H. J. Mackinder, M.A..........	The Movements of Men by Land and Sea.
1902. Belfast......	Prof. L. C. Miall, F.R.S.	Gnats and Mosquitoes.
1903. Southport	Dr. J. S. Flett	Martinique and St. Vincent: the Eruptions of 1902.
1904. Cambridge	Dr. J. E. Marr, F.R.S.	The Forms of Mountains.

OFFICERS OF SECTIONAL COMMITTEES PRESENT AT THE SOUTH AFRICA MEETING.

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Secretaries.—C. W. Kimmins, M.A., D.Sc. (*Recorder*); A. D. Hall, M.A.; Prof. Hele-Shaw, LL.D., F.R.S.; J. R. Whitton.

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The President and Vice-Presidents of the Meeting; the Presidents of former years; the Trustees; the General Treasurer; the General Secretaries; Prof. Forsyth; Prof. Hicks; Dr. Lees; G. T. Beilby; Dr. Horace Brown; Prof. Henderson; Prof. Miers; Prof. Sollas; H. L. Bowman; G. A. Boulenger; Prof. Poulton; Prof. Simpson; Admiral Sir W. J. L. Wharton; Dr. H. R. Mill; Dr. Herbertson; Rev. Dr. Cunningham; Hon. Sir C. Fremantle, A. L. Bowley; Col. Sir C. Scott-Moncrieff; Sir W. H. Preece; W. Bayley Marshall; Dr. A. C. Haddon; H. Balfour; E. S. Hartland; Colonel D. Bruce; Prof. Halliburton; J. Barcroft; H. Wager; A. C. Seward; Prof. Yapp; Sir R. C. Jebb; Rev. J. O. Bevan; and Dr. Kimmins.

Dr. THE GENERAL TREASURER'S ACCOUNT,

1904–1905 RECEIPTS.

	£	s.	d.
Balance brought forward	1410	0	10
Life Compositions (including Transfers)	721	0	0
New Annual Members' Subscriptions	532	0	0
Annual Subscriptions	720	0	0
Sale of Associates' Tickets	1318	0	0
Sale of Ladies' Tickets	317	0	0
Sale of Publications	257	12	0
Dividend on Consols	154	8	4
Dividend on India 3 per Cents.	102	12	0
Interest on Deposit	40	8	7
Balance of Grants returned	19	14	2
	£5592	15	11

Investments.

	£	s.	d.
$2\frac{1}{2}$ per Cent. Consolidated Stock	6501	10	5
India 3 per Cent. Stock	3600	0	0
	£10,101	10	5
Sir Frederick Bramwell's Gift, $2\frac{1}{2}$ per Cent. Self-cumulating Consolidated Stock	60	0	8
	£10,161	11	1

JOHN PERRY, *General Treasurer.*

from July 1, 1904, to June 30, 1905. *Cr.*

1904–1905. PAYMENTS.

				£	s.	d.
Expenses of Cambridge Meeting (including Printing, Advertising, Payment of Clerks, &c.)				230	7	5
Rent and Office Expenses (including repairs, renovating and furnishing additional room, installation of telephone, &c.)				136	19	11
Salaries, &c.				565	8	10
Printing, Binding, &c. (£999 2*s.* 9*d.* on account of 1904)				1940	17	7
Repair of Banners				3	11	11
Payment of Grants made at Cambridge:	£	s.	d.			
Electrical Standards	40	0	0			
Seismological Observations	40	0	0			
Investigation of the Upper Atmosphere by means of Kites	40	0	0			
Magnetic Observations at Falmouth	50	0	0			
Wave-length Tables of Spectra	5	0	0			
Study of Hydro-aromatic Substances	25	0	0			
Dynamic Isomerism	20	0	0			
Aromatic Nitramines	25	0	0			
Fauna and Flora of the British Trias	10	0	0			
Table at the Zoological Station, Naples	100	0	0			
Index Generum et Specierum Animalium	75	0	0			
Development in the Frog	10	0	0			
Investigations in the Indian Ocean	150	0	0			
Trade Statistics	4	4	8			
Researches in Crete	75	0	0			
Anthropometric Investigations on Egyptian Troops	10	0	0			
Excavations on Roman Sites in Britain	10	0	0			
Anthropometric Investigations	10	0	0			
Age of Stone Circles	30	0	0			
The State of Solution of Proteids	20	0	0			
Metabolism of Individual Tissues	30	0	0			
Ductless Glands	40	0	0			
Botanical Photographs	3	17	6			
Physiology of Heredity	35	0	0			
Structure of Fossil Plants	50	0	0			
Corresponding Societies Committee	20	0	0			
				928	2	2
				3805	7	10
On deposit at Bradford District Bank				918	1	11
Balance at Bank of England (Western Branch)	£1734	9	1			
Less Cheques not presented	867	14	10			
				866	14	3
Cash in hand				2	11	11
				£5592	15	11

I have examined the above Account with the books and vouchers of the Association, and certify the same to be correct. I have also verified the balance at the Bankers', and have ascertained that the Investments are registered in the names of the Trustees.

Approved—
EDWARD BRABROOK, } *Auditors.*
HENRY HIGGS, }

W. B. KEEN, *Chartered Accountant,*
3 Church Court, Old Jewry, E.C.
July 11, 1905.

Table showing the Attendance and Receipts

Date of Meeting	Where held	Presidents	Old Life Members	New Life Members
1831, Sept. 27	York	The Earl Fitzwilliam, D.C.L., F.R.S.	—	—
1832, June 19	Oxford	The Rev. W. Buckland, F.R.S.	—	—
1833, June 25	Cambridge	The Rev. A. Sedgwick, F.R.S.	—	—
1834, Sept. 8	Edinburgh	Sir T. M. Brisbane, D.C.L., F.R.S. ...	—	—
1835, Aug. 10	Dublin	The Rev. Provost Lloyd, LL.D., F.R.S.	—	—
1836, Aug. 22	Bristol	The Marquis of Lansdowne, F.R.S....	—	—
1837, Sept. 11	Liverpool	The Earl of Burlington, F.R.S.	—	—
1838, Aug. 10	Newcastle-on-Tyne...	The Duke of Northumberland, F.R.S.	—	—
1839, Aug. 26	Birmingham	The Rev. W. Vernon Harcourt, F.R.S.	—	—
1840, Sept. 17	Glasgow	The Marquis of Breadalbane, F.R.S.	—	—
1841, July 20	Plymouth	The Rev. W. Whewell, F.R.S.	169	65
1842, June 23	Manchester	The Lord Francis Egerton, F.G.S. ...	303	169
1843, Aug. 17	Cork	The Earl of Rosse, F.R.S.	109	28
1844, Sept. 26	York	The Rev. G. Peacock, D.D., F.R.S. ...	226	150
1845, June 19	Cambridge	Sir John F. W. Herschel, Bart., F.R.S.	313	36
1846, Sept. 10 ...	Southampton	Sir Roderick I. Murchison, Bart., F.R.S.	241	10
1847, June 23	Oxford	Sir Robert H. Inglis, Bart., F.R.S. ...	314	18
1848, Aug. 9	Swansea	The Marquis of Northampton, Pres. R.S.	149	3
1849, Sept. 12	Birmingham	The Rev. T. R. Robinson, D.D., F.R.S.	227	12
1850, July 21	Edinburgh	Sir David Brewster, K.H., F.R.S.	235	9
1851, July 2	Ipswich	G. B. Airy, Astronomer Royal, F.R.S.	172	8
1852, Sept. 1	Belfast	Lieut.-General Sabine, F.R.S.	164	10
1853, Sept. 3	Hull	William Hopkins, F.R.S.	141	13
1854, Sept. 20	Liverpool	The Earl of Harrowby, F.R.S.	238	23
1855, Sept. 12	Glasgow	The Duke of Argyll, F.R.S.	194	33
1856, Aug. 6	Cheltenham	Prof. C. G. B. Daubeny, M.D., F.R.S....	182	14
1857, Aug. 26	Dublin	The Rev. H. Lloyd, D.D., F.R.S.	236	15
1858, Sept. 22	Leeds	Richard Owen, M.D., D.C.L., F.R.S....	222	42
1859, Sept. 14	Aberdeen	H.R.H. The Prince Consort	184	27
1860, June 27	Oxford	The Lord Wrottesley, M.A., F.R.S. ...	286	21
1861, Sept. 4	Manchester	William Fairbairn, LL.D., F.R.S.	321	113
1862, Oct. 1	Cambridge	The Rev. Professor Willis, M.A., F.R.S.	239	15
1863, Aug. 26	Newcastle-on-Tyne...	Sir William G. Armstrong, C.B., F.R.S.	203	36
1864, Sept. 13	Bath	Sir Charles Lyell, Bart., M.A., F.R.S.	287	40
1865, Sept. 6	Birmingham	Prof. J. Phillips, M.A., LL.D., F.R.S.	292	44
1866, Aug. 22	Nottingham	William R. Grove, Q.C., F.R.S.	207	31
1867, Sept. 4	Dundee	The Duke of Buccleuch, K.C.B., F.R.S.	167	25
1868, Aug. 19	Norwich	Dr. Joseph D. Hooker, F.R.S.	196	18
1869, Aug. 18	Exeter	Prof. G. G. Stokes, D.C.L., F.R.S.	204	21
1870, Sept. 14	Liverpool	Prof. T. H. Huxley, LL.D., F.R.S. ...	314	39
1871, Aug. 2	Edinburgh	Prof. Sir W. Thomson, LL.D., F.R.S.	246	28
1872, Aug. 14	Brighton	Dr. W. B. Carpenter, F.R.S.	245	36
1873, Sept. 17	Bradford	Prof. A. W. Williamson, F.R.S.	212	27
1874, Aug. 19	Belfast	Prof. J. Tyndall, LL.D., F.R.S.	162	13
1875, Aug. 25	Bristol	Sir John Hawkshaw, F.R.S.	239	36
1876, Sept. 6	Glasgow	Prof. T. Andrews, M.D., F.R.S.	221	35
1877, Aug. 15	Plymouth	Prof. A. Thomson, M.D., F.R.S.	173	19
1878, Aug. 14	Dublin	W. Spottiswoode, M.A., F.R.S.	201	18
1879, Aug. 20	Sheffield	Prof. G. J. Allman, M.D., F.R.S.	184	16
1880, Aug. 25	Swansea	A. C. Ramsay, LL.D., F.R.S.	144	11
1881, Aug. 31	York	Sir John Lubbock, Bart., F.R.S.	272	28
1882, Aug. 23	Southampton	Dr. C. W. Siemens, F.R.S.	178	17
1883, Sept. 19	Southport	Prof. A. Cayley, D.C.L., F.R.S.	203	60
1884, Aug. 27	Montreal	Prof. Lord Rayleigh, F.R.S.	235	20
1885, Sept. 9	Aberdeen	Sir Lyon Playfair, K.C.B., F.R.S.	225	18
1886, Sept. 1	Birmingham	Sir J. W. Dawson, C.M.G., F.R.S.	314	25
1887, Aug. 31	Manchester	Sir H. E. Roscoe, D.C.L., F.R.S.	428	86
1888, Sept. 5	Bath	Sir F. J. Bramwell, F.R.S.	266	36
1889, Sept. 11	Newcastle-on-Tyne...	Prof. W. H. Flower, C.B., F.R.S.	277	20
1890, Sept. 3	Leeds	Sir F. A. Abel, C.B., F.R.S.	259	21
1891, Aug. 19	Cardiff	Dr. W. Huggins, F.R.S.	189	24
1892, Aug. 3	Edinburgh	Sir A. Geikie, LL.D., F.R.S.	280	14
1893, Sept. 13	Nottingham	Prof. J. S. Burdon Sanderson, F.R.S.	201	17
1894, Aug. 8	Oxford	The Marquis of Salisbury, K.G., F.R.S.	327	21
1895, Sept. 11	Ipswich	Sir Douglas Galton, K.C.B., F.R.S. ...	214	13
1896, Sept. 16	Liverpool	Sir Joseph Lister, Bart., Pres. R.S. ...	330	31
1897, Aug. 18	Toronto	Sir John Evans, K.C.B., F.R.S.	120	8
1898, Sept. 7	Bristol	Sir W. Crookes, F.R.S.	281	19
1899, Sept. 13	Dover	Sir Michael Foster, K.C.B., Sec.R.S....	296	20
1900, Sept. 5	Bradford	Sir William Turner, D.C.L., F.R.S. ...	267	13
1901, Sept. 11	Glasgow	Prof. A. W. Rücker, D.Sc., Sec.R.S. ...	310	37
1902, Sept. 10	Belfast	Prof. J. Dewar, LL.D., F.R.S.	243	21
1903, Sept. 9	Southport	Sir Norman Lockyer, K.C.B., F.R.S.	250	21
1904, Aug. 17	Cambridge	Rt. Hon. A. J. Balfour, M.P., F.R.S.	419	32
1905, Aug. 15	South Africa	Prof. G. H. Darwin, LL.D., F.R.S. ...	115	40

* Ladies were not admitted by purchased tickets until 1843. † Tickets of Admission to Sections only.

at Annual Meetings of the Association.

Old Annual Members	New Annual Members	Associates	Ladies	Foreigners	Total	Amount received during the Meeting	Grants for Scientific Purposes	Year
—	—	—	—	—	353	—	—	1831
—	—	—	—	—	—	—	—	1832
—	—	—	—	—	900	—	—	1833
—	—	—	—	—	1298	—	£20 0 0	1834
—	—	—	—	—	—	—	167 0 0	1835
—	—	—	—	—	1350	—	435 0 0	1836
—	—	—	—	—	1840	—	922 12 6	1837
—	—	—	1100*	—	2400	—	932 2 2	1838
—	—	—	—	34	1438	—	1595 11 0	1839
—	—	—	—	40	1353	—	1546 16 4	1840
46	317	—	60*	—	891	—	1235 10 11	1841
75	376	33†	331*	28	1315	—	1449 17 8	1842
71	185	—	160	—	—	—	1565 10 2	1843
45	190	9†	260	—	—	—	981 12 8	1844
94	22	407	172	35	1079	—	831 9 9	1845
65	39	270	196	36	857	—	685 16 0	1846
197	40	495	203	53	1320	—	208 5 4	1847
54	25	376	197	15	819	£707 0 0	275 1 8	1848
93	33	447	237	22	1071	963 0 0	159 19 6	1849
128	42	510	273	44	1241	1085 0 0	345 18 0	1850
61	47	244	141	37	710	620 0 0	391 9 7	1851
63	60	510	292	9	1108	1085 0 0	304 6 7	1852
56	57	367	236	6	876	903 0 0	205 0 0	1853
121	121	765	524	10	1802	1882 0 0	380 19 7	1854
142	101	1094	543	26	2133	2311 0 0	480 16 4	1855
104	48	412	346	9	1115	1098 0 0	734 13 9	1856
156	120	900	569	26	2022	2015 0 0	507 15 4	1857
111	91	710	509	13	1698	1931 0 0	618 18 2	1858
125	179	1206	821	22	2564	2782 0 0	684 11 1	1859
177	59	636	463	47	1689	1604 0 0	766 19 6	1860
184	125	1589	791	15	3138	3944 0 0	1111 5 10	1861
150	57	433	242	25	1161	1089 0 0	1293 16 6	1862
154	209	1704	1004	25	3335	3640 0 0	1608 3 10	1863
182	103	1119	1058	13	2802	2965 0 0	1289 15 8	1864
215	149	766	508	23	1997	2227 0 0	1591 7 10	1865
218	105	960	771	11	2303	2469 0 0	1750 13 4	1866
193	118	1163	771	7	2444	2613 0 0	1739 4 0	1867
226	117	720	682	45‡	2004	2042 0 0	1940 0 0	1868
229	107	678	600	17	1856	1931 0 0	1622 0 0	1869
303	195	1103	910	14	2878	3096 0 0	1572 0 0	1870
311	127	976	754	21	2463	2575 0 0	1472 2 6	1871
280	80	937	912	43	2533	2649 0 0	1285 0 0	1872
237	99	796	601	11	1983	2120 0 0	1685 0 0	1873
232	85	817	630	12	1951	1979 0 0	1151 16 0	1874
307	93	884	672	17	2248	2397 0 0	960 0 0	1875
331	185	1265	712	25	2774	3023 0 0	1092 4 2	1876
238	59	446	283	11	1229	1268 0 0	1128 9 7	1877
290	93	1285	674	17	2578	2615 0 0	725 16 6	1878
239	74	529	349	13	1404	1425 0 0	1080 11 11	1879
171	41	389	147	12	915	899 0 0	731 7 7	1880
313	176	1230	514	24	2557	2689 0 0	476 8 1	1881
253	79	516	189	21	1253	1286 0 0	1126 1 11	1882
330	323	952	841	5	2714	3369 0 0	1083 3 3	1883
317	219	826	74	26 & 60 H.§	1777	1855 0 0	1173 4 0	1884
332	122	1053	447	6	2203	2256 0 0	1385 0 0	1885
428	179	1067	429	11	2453	2532 0 0	995 0 6	1886
510	244	1985	493	92	3838	4336 0 0	1186 18 0	1887
399	100	639	509	12	1984	2107 0 0	1511 0 5	1888
412	113	1024	579	21	2437	2441 0 0	1417 0 11	1889
368	92	680	334	12	1775	1776 0 0	789 16 8	1890
341	152	672	107	35	1497	1664 0 0	1029 10 0	1891
413	141	733	439	50	2070	2007 0 0	864 10 0	1892
328	57	773	268	17	1661	1653 0 0	907 15 6	1893
435	69	941	451	77	2321	2175 0 0	583 15 6	1894
290	31	493	261	22	1324	1236 0 0	977 15 5	1895
383	139	1384	873	41	3181	3228 0 0	1104 6 1	1896
286	125	682	100	41	1362	1398 0 0	1059 10 8	1897
327	96	1051	639	33	2446	2399 0 0	1212 0 0	1898
324	68	548	120	27	1403	1328 0 0	1430 14 2	1899
297	45	801	482	9	1915	1801 0 0	1072 10 0	1900
374	131	794	246	20	1912	2046 0 0	945 0 0	1901
314	86	647	305	6	1620	1644 0 0	947 0 0	1902
319	90	688	365	21	1754	1762 0 0	845 13 2	1903
449	113	1338	317	121	2789	2650 0 0	887 18 11	1904
937¶	411	430	181	16	2130	2422 0 0	928 2 2	1905

‡ Including Ladies. § Fellows of the American Association were admitted as Hon. Members for this Meeting.
¶ Including 848 Members of the South African Association.

OFFICERS AND COUNCIL, 1905–1906.

PATRON.

HIS MAJESTY THE KING.

PRESIDENT.

PROFESSOR SIR G. H. DARWIN, K.C.B., M.A., LL.D., Ph.D., F.R.S.

VICE-PRESIDENTS.

His Excellency the Right Hon. the EARL OF SELBORNE, G.C.M.G., High Commissioner for South Africa.
The Right Hon. LORD MILNER, G.C.B., G.C.M.G., late High Commissioner for South Africa.
His Excellency the Hon. Sir WALTER F. HELY-HUTCHINSON, G.C.M.G., Governor of Cape Colony.
His Excellency Colonel Sir HENRY E. McCALLUM, G.C.M.G., R.E., Governor of Natal.
His Excellency Captain the Hon. Sir ARTHUR LAWLEY, K.C.M.G., Lieutenant-Governor, Transvaal.
His Excellency Major Sir H. J. GOOLD-ADAMS, K.C.M.G., Lieutenant-Governor, Orange River Colony.
His Honour Sir W. H. MILTON, K.C.M.G., Administrator of Southern Rhodesia.
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Sir DAVID GILL, K.C.B., LL.D., D.Sc., F.R.S., H.M. Astronomer, Cape Colony.
THEODORE REUNERT, M.Inst.C.E.
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The MAYOR OF JOHANNESBURG.
The PRESIDENT OF THE PHILOSOPHICAL SOCIETY OF SOUTH AFRICA.
The MAYOR OF DURBAN.
The MAYOR OF PIETERMARITZBURG.
The MAYOR OF BLOEMFONTEIN.
The MAYOR OF PRETORIA.
The MAYOR OF KIMBERLEY.
The MAYOR OF BULAWAYO.

PRESIDENT ELECT.

Professor E. RAY LANKESTER, M.A., LL.D., D.Sc., F.R.S., F.L.S.

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The Right Hon. the LORD MAYOR OF YORK.
The HIGH SHERIFF OF YORKSHIRE.
The Most Hon. the MARQUESS OF RIPON, K.G., G.C.S.I., C.I.E., D.C.L., F.R.S.
The Right Rev. the LORD BISHOP OF RIPON, D.D., D.C.L.
The Right Hon. the EARL OF FEVERSHAM.
The Right Hon. LORD WENLOCK, G.C.S.I., G.C.I.E., K.C.B.
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TEMPEST ANDERSON, M.D., D.Sc.

GENERAL TREASURER.

Professor JOHN PERRY, D.Sc., LL.D., F.R.S.

GENERAL SECRETARIES.

Major P. A. MACMAHON, R.A., D.Sc., F.R.S. | Professor W. A. HERDMAN, D.Sc., F.R.S.

ASSISTANT SECRETARY.

A. SILVA WHITE, Burlington House, London, W.

CHIEF CLERK AND ASSISTANT TREASURER.

H. C. STEWARDSON, Burlington House, London, W.

LOCAL TREASURER FOR THE MEETING AT YORK.

Sir JOSEPH SYKES RYMER.

LOCAL SECRETARIES FOR THE MEETING AT YORK.

— | C. E. ELMHIRST.

ORDINARY MEMBERS OF THE COUNCIL.

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BOWER, Professor F. O., F.R.S.
BOYS, C. VERNON, F.R.S.
BRABROOK, Sir E. W., C.B.
BROWN, Dr. HORACE T., F.R.S.
CALLENDAR, Professor H. L., F.R.S.
CUNNINGHAM, Professor D. J., F.R.S.
DUNSTAN, Professor W., F.R.S.
DYSON, F. W., F.R.S.
GLAZEBROOK, Dr. R. T., F.R.S.
GOTCH, Professor F., F.R.S.
HADDON, Dr. A. C., F.R.S.
HAWKSLEY, C., M.Inst.C.E.
HIGGS, HENRY, LL.B.
LANGLEY, Professor J. N., F.R.S.
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NOBLE, Sir A., Bart., K.C.B., F.R.S.
PERKIN, Professor W. H., F.R.S.
POULTON, Professor E. B., F.R.S.
SEWARD, A. C., F.R.S.
SHAW, Dr. W. N., F.R.S.
SHIPLEY, A. E., F.R.S.
WATTS, Professor W. W., F.R.S.
WOODWARD, Dr. A. SMITH, F.R.S.

EX-OFFICIO MEMBERS OF THE COUNCIL.

The Trustees, the President and President Elect, the Presidents of former years, the Vice-Presidents and Vice-Presidents Elect, the General Secretaries for the present and former years, the former Assistant General Secretaries, the General Treasurers for the present and former years, and the Local Treasurer and Secretaries for the ensuing Meeting.

TRUSTEES (PERMANENT).

The Right Hon. Lord AVEBURY, D.C.L., LL.D., F.R.S., F.L.S.
The Right Hon. Lord RAYLEIGH, M.A., D.C.L., LL.D., F.R.S., F.R.A.S.
Sir ARTHUR W. RÜCKER, M.A., D.Sc., F.R.S.

PRESIDENTS OF FORMER YEARS.

Sir Joseph D. Hooker, G.C.S.I.
Lord Kelvin, G.C.V.O., F.R.S.
Lord Avebury, D.C.L., F.R.S.
Lord Rayleigh, D.C.L., Pres.R.S.
Sir H. E. Roscoe, D.C.L., F.R.S.
Sir Wm. Huggins, K.C.B., F.R.S.
Sir Archibald Geikie, Sec.R.S.
Lord Lister, D.C.L., F.R.S.
Sir John Evans, K.C.B., F.R.S.
Sir William Crookes, F.R.S.
Sir Michael Foster, K.C.B., F.R.S.
Sir W. Turner, K.C.B., F.R.S.
Sir A. W. Rücker, D.Sc., F.R.S.
Prof. J. Dewar, LL.D., F.R.S.
Sir Norman Lockyer, K.C.B. F.R.S.
Rt. Hon. A. J. Balfour, D.C.L. F.R.S.

GENERAL OFFICERS OF FORMER YEARS.

F. Galton, D.C.L., F.R.S.
Sir Michael Foster, K.C.B., F.R.S.
P. L. Sclater, Ph.D., F.R.S.
Prof. T. G. Bonney, D.Sc., F.R.S.
A. Vernon Harcourt, F.R.S.
Sir A. W. Rücker, D.Sc., F.R.S.
Prof. E. A. Schäfer, F.R.S.
Dr. D. H. Scott, M.A., F.R.S.
Dr. G. Carey Foster, F.R.S.
Dr. J. G. Garson.

AUDITORS.

Sir Edward Brabrook, C.B. | Henry Higgs, LL.B.

Report *of the* **Council** *for the year* 1904–1905, *presented to the* **General Committee** *at the Sitting in Cape Town, South Africa, on Tuesday, August* 15, *at* 4.0 P.M.

I. The arrangements for the Meeting of the Association in South Africa have been directed, under the sanction of the Council, by a special South African Committee, sitting in London, and consisting of the General Officers of the Association (the President and President-Elect, the General Treasurer, and the General Secretaries), Professor Armstrong, Dr. Horace Brown, Sir William Crookes, Sir James Dewar, Sir Archibald Geikie, Professor H. A. Miers, Sir Henry Roscoe, and Dr. Sclater. The co-ordination of the work of the various Local Committees has been carried out under the direction of the Central Organising Committee for South Africa, sitting at Cape Town, consisting of Sir David Gill (Chairman) and Dr. J. D. F. Gilchrist (Secretary).

An Additional Expenses Fund having been opened to supplement the subvention of 6,000*l.* from the South African Colonies, contributions amounting to 3,100*l.* have been received and encashed.

The appointment of Vice-Presidents of the Association having been left by the General Committee in the hands of the Council, the following gentlemen have been appointed :—

His Excellency the Right Hon. Lord Milner, G.C.B., G.C.M.G., formerly High Commissioner for South Africa.

His Excellency the Right Hon. the Earl of Selborne, G.C.M.G., High Commissioner for South Africa.

His Excellency the Hon. Sir Walter F. Hely-Hutchinson, G.C.M.G., Governor of Cape Colony.

His Excellency Colonel Sir Henry E. McCallum, G.C.M.G., R.E., Governor of Natal.

His Excellency Captain the Hon. Sir Arthur Lawley, K.C.M.G., Lieutenant-Governor, Transvaal.

His Excellency Major Sir H. J. Goold-Adams, K.C.M.G., Lieutenant-Governor, Orange River Colony.

His Honour Sir W. H. Milton, K.C.M.G., Administrator of Southern Rhodesia.

Sir David Gill, K.C.B., LL.D., D.Sc., F.R.S., His Majesty's Astronomer, Cape of Good Hope.

Sir Charles H. T. Metcalfe, Bart., M.A.

Theodore Reunert, M.Inst.C.E.

The Mayor of Cape Town.

The Mayor of Johannesburg.

The President of the Philosophical Society of South Africa.

The Mayor of Durban.

The Mayor of Pietermaritzburg.

The Mayor of Bloemfontein.

The Mayor of Pretoria.

The Mayor of Kimberley.

The Mayor of Bulawayo.

II. The following Agreement has been made between the British Association and the South African Association in the matter of financial arrangements respecting the Annual Meeting in 1905 :—

(i) That all Members (but not Associates) of the South African Association shall be entitled to Associates' Tickets at the Meeting of the British Association in South Africa in 1905.

(ii) That the South African Association shall pay a contribution of 500*l.* to the funds of the British Association.

(iii) The South African Association guarantees the purchase of a thousand copies at least of the Annual Volume, the copies to be sent direct to the Members of the South African Association on payment to the British Association by the South African Association of the sum of 8*s.* per copy.

III. A Committee of the Council, consisting of Professor G. H. Darwin, Sir A. Geikie, the General Secretaries, and the General Treasurer, was authorised to consider the appointment of an ASSISTANT SECRETARY, in succession to Dr. Garson, resigned, with the result that Mr. A. Silva White was unanimously appointed to fill that office.

IV. The books and other publications presented to or received in exchange by the Association, with the exception of the publications of the Corresponding Societies of the Association and the Annual Volumes of Reports of the various Associations for the Advancement of Science, have been transferred to the Library of University College, Gower Street, the Council of University College having undertaken to give the same facilities to Members of the British Association for the use of University College Library as were granted under similar circumstances by the University of London.

V. The following RESOLUTION, from the Committee of Section A, having been referred to a Committee consisting of Dr. A. Buchan, Dr. H. R. Mill, Dr. Shaw, and the General Officers, to consider and report thereon to the Council :—

> The Committee of Section A desire to draw the attention of the Committee of Recommendations to the concluding portion of Sir John Eliot's Introductory Address to the Sub-Section for Astronomy and Cosmical Physics, and to express the opinion that the organisation of a Central Meteorological Department for the British Empire would be of the highest benefit to the progress of Meteorological Science and its application to the economic problems of the various Colonies and Dependencies. The object of each department would be to collect and prepare digests of the Meteorological observations taken in different parts of the Empire, to provide a scientific staff for dealing with the more general Meteorological problems, including their relations to Solar Physics and Terrestrial Magnetism, which involve the co-ordination of data from wide areas, and to promote experimental investigations of the scientific questions which arise in connection with such discoveries. The Committee desire also to express the opinion that the reorganisation of the Meteorological Office, which is at present before the Government, affords an exceptionally favourable opportunity for the establishment of such a Central Meteorological Department for the Empire.

The MEMORANDUM that follows was drawn up by the Committee and has been approved by the Council :—

Memorandum on a Proposal for dealing with Meteorological Questions affecting the British Dominions beyond the Seas.

There is at present no provision for the systematic treatment of the meteorology of the British dominions.

Observations of various kinds are made in nearly all the British Colonies and Dependencies, and summaries of these observations are generally included in the respective official publications. India, Ceylon, Canada, the several States of Australia, New Zealand, Mauritius, the Cape of Good Hope, and the Transvaal have organised meteorological establishments and issue regular meteorological publications. Information with regard to the meteorology of the Crown Colonies and Protectorates is to be found in the Blue-books of the several dominions.

There is no provision for the co-ordination of the methods of observing, the instruments employed, or the presentation of results.

In 1890 the Meteorological Council published a volume of summaries of Colonial observations of the Army Medical Department and of the Royal

Engineers, and recently they have published a volume of tables for tropical Africa, compiled by Mr. E. G. Ravenstein from observations practically initiated by a Committee of the British Association.

Colonial observations are sent to the Meteorological Office in accordance with a circular despatch of Mr. Chamberlain.

At the request of the Crown Agents, the Meteorological Council have recently undertaken the supervision of the supply of instruments for the Governments of the Crown Colonies. In their annual reports they have from time to time referred to the desirability of the compilation and regular issue of the results, but they have been unable to make provision for this service.

The want of a satisfactory system of co-ordinating the observations from the several dominions is to be deplored from two points of view—the economic and the scientific.

From the economic point of view, it is eminently desirable that facilities should be given for the comparison of the climatic features of the regions available for settlement and the conditions which affect various industries. At present it is possible to obtain a certain amount of information for an individual Colony by reference to Colonial Blue-books, but the data are of very different orders of completeness; and to ascertain in which Colonies specified climatic conditions are to be found would be a labour of such difficulty as to be practically prohibitive. The Board of Trade publish a certain number of tables of meteorological results among their Colonial statistics, but something of a more comprehensive character is required.

From the scientific point of view the regular issue of the meteorological data for the British Colonies in a published and easily accessible form is urgently desired by meteorologists of all countries. This is sufficiently shown by the following extract from a notice of the recent publication of the results for tropical Africa in the *Meteorologische Zeitschrift*, the leading meteorological journal:—

'To the Meteorological Council the warmest thanks of all meteorologists are due for their resolution to publish from time to time the reports of observations at colonial or foreign stations, which are collected in the Meteorological Office partly in printed form and partly in manuscript. In this journal we have repeatedly pointed out that it is in the highest degree desirable that the rich store of observations which have accumulated in the Meteorological Office, and which might be of great importance for the physics of the atmosphere as a whole, should be made generally known and available. . . . It is very desirable that this valuable publication may soon be continued.'

But there is another aspect from which the scientific treatment of meteorological data must be regarded as having an important bearing upon the economic interests of remote parts of the Empire.

Sir John Eliot, in his address to the British Association meeting at Cambridge, pointed out how the study of the meteorological conditions of the Indian Ocean and the bordering countries had been already applied to problems affecting the economic conditions of India as depending upon the variation of the monsoon rainfall, and he gave reasons for believing that the further prosecution of the inquiry promises valuable results for India, Australia, South and East Africa, and other countries bordering on the Indian Ocean if provision were made for dealing with the meteorological problem in a comprehensive manner with reference to the Indian Ocean as a whole.

Similar reasoning may be held to apply also to other oceanic areas, in or on the border of which British Colonies are situated. In this connection it should, perhaps, be mentioned that the control of the meteorological organisation of the British West Indies is already passing into the hands of the United States.

As a result of Sir John Eliot's representation, the attention of the Council of the British Association has been called to the advantages likely to accrue from the organised study of the meteorological problems affecting various groups of British dominions.

It has been further pointed out that such organised study can be most effectively secured by the establishment of a central institution devoted to these objects. Such an institution ought to be in close connection with the Meteorological Office, which is itself in regular correspondence with the

meteorological organisations of foreign countries as well as those of the self-governing Colonies. The meteorology of the ocean has been an essential part of the work of the office from its establishment in 1854, and oceanic data must necessarily be appealed to for the effective study of the meteorology of the neighbouring land areas.

The President and Council of the British Association are informed that the Meteorological Office, as at present constituted, has not the means of dealing effectively with the various problems of Colonial meteorology, and the suggested institution would have to be a distinct department with separate provision, whether it was in organic connection with the Office or not.

The President and Council believe that the Government of India, from their interest in meteorological investigations, would be willing to contribute their fair share towards the maintenance of such an institution, and they desire to bring the matter to the notice of the Secretary of State for the Colonies with the view of ascertaining the opinion of the various Colonies which are interested in the subject. They desire to learn whether they would be supported in an effort to obtain the establishment of such an institution as had been described.

By way of summary, the objects of the suggested institution may be briefly stated to be :—

1. To give any information that may be required to the Governments or other authorities of the British dominions as to instruments and methods to be adopted for an effective system of meteorological observations.

2. To compile and publish periodical reports upon the climatic conditions of the various parts of the Empire upon a comparable plan. To form an accessible depository of information upon matters concerning the climates of the whole Empire, and to afford information upon those subjects to inquirers.

3. To provide a scientific staff for the study of the general meteorological conditions which affect the weather in the various British dominions, and in particular to promote the formulation of meteorological laws, and to apply them to explain and ultimately to anticipate the occurrences of abnormal seasons.

A copy of this Memorandum having been forwarded to the Colonial Office, with a covering-letter suggesting that the question might be moved by a deputation to the Secretary of State, Mr. Lyttelton replied that, whilst sympathising with the object which the Council had in view, he did not think that there would be any advantage in receiving a deputation until he was in possession of further information on the subject. In satisfaction of this request, the Committee drafted the following additional information :—

Draft Memorandum in further explanation of the proposal for dealing with the Meteorology of the Colonies and Dependencies, for the information of the Secretary of State.

This memorandum deals mainly with the object numbered 3 in the concluding summary of the memorandum approved by the President and Council on March 3, 1905, because the services indicated under numbers 1 and 2 would be included incidentally in the development of number 3.

The statement of the object numbered 3 is as follows:—

To provide a scientific staff for the study of the general meteorological conditions which affect the weather in the several British dominions, and in particular to promote the formulation of meteorological laws, and to apply them to explain and ultimately to anticipate the occurrence of abnormal seasons.

The idea underlying the proposal is to deal with the general meteorological conditions of wider areas than those with which the various meteorological

offices of the world have hitherto been regarded as being primarily concerned. The British Meteorological Office does indeed concern itself with the meteorology of the oceans from the point of view of shipping. In effect, the proposal is to utilise further the information already obtained at sea in conjunction with land observations for the investigation of the meteorology of large ocean areas in relation to that of the adjacent land areas, and from the point of view of the land population.

It is known, for example, that the meteorological conditions of India, Australia, South Africa, East Africa, and Egypt stand in close relation to those of the Indian Ocean, and the study of these relations promises very important results in connection with the prediction of the seasons. This investigation requires that the information shall be treated in a manner different from that now followed for the more immediate purpose of its application to the interests of shipping.

The meteorological phenomena which are regarded as demanding careful study, in the first instance, are the following:—

The conditions of favourable and unfavourable seasons in India.
The droughts of Australia and South Africa.
The conditions of favourable and unfavourable Nile floods.

With those would be associated the relation of the weather of the Mediterranean to the Indian cold weather anomalies, and the relation of the South Indian anticyclone to the Antarctic ice.

The larger part of the necessary land data for the investigation of these particular questions can probably be found in the publications of the meteorological organisations of India, Australia, South and East Africa, Egypt, Mauritius, Hong Kong, Singapore, or can be furnished directly by those organisations. They should be supplemented by observations contributed by certain foreign Governments. The marine data would have to be compiled from the documents collected from ships by the meteorological departments of this country and India. The further development of the collection of observations—more especially of marine data—might be necessary, in order to complete the investigation.

The use of the data would be, in the first instance, to obtain a survey of the sequence of the more general weather changes over the whole region under consideration. The first step in the operations therefore would be to consider the nature and extent of the data available for the purposes in view, and the form in which they should be compiled for study or for publication.

A corresponding inquiry for the Atlantic Ocean and the countries bordering upon it is equally desirable, and should be conducted concurrently in the interests of the British Isles and the American and West Indian Colonies.

In order to carry out the proposal, something more than what would be generally understood by 'a moderate addition to the staff of the Meteorological Office' is required. The proposal involves a scientific investigation of a very important character which could not be regarded as merely an incidental addition to the usual operations of the Office. A man of suitable scientific attainments should be responsible for conducting it in consultation with, and under the general supervision of, the Director of the Meteorological Office. It is desirable to mark the nature of the qualifications expected in the person to whom the work is entrusted by giving him the title of Assistant Director and providing a salary of from 400*l.* to 600*l.* a year. It should be remembered also that the Meteorological Office could not find accommodation for the proposed additional staff without some addition to the space at present available.

It is estimated that the annual cost of the work would be 2,000*l.*, rising in five years to 2,500*l.* made up as follows:—

SALARIES:	Assistant Director	£450 to £550
	Scientific assistant, computers and clerical staff	1,050 to 1,300
PUBLICATIONS, printing and stationery		300 to 500
INCIDENTAL EXPENSES, office rent, &c.		200 to 150

The estimate is based on the supposition that the Meteorological

Committee would be willing to undertake the general control of the department as a branch of the Meteorological Office.

It may be mentioned that the Government grant to the Meteorological Office at present stands at 15,300*l* The cost of the marine department, as shown in the Report of the Meteorological Council for 1903–4, is 1,366*l*., exclusive of office expenses, publications, &c.

THE COUNCIL, in approving this Memorandum, has caused it to be conveyed under a covering-letter to the Secretary of State for the Colonies.

VI. The following RESOLUTION, from the Conference of Delegates, was referred to the Council by the General Committee for consideration and action, if desirable :

(i) That a Committee be appointed, consisting of Members of the Council of the Association, together with representatives of the Corresponding Societies, to consider the present relation between the British Association and local Scientific Societies.

(ii) That the Committee be empowered to make suggestions to the Council with a view to the greater utilisation of the connection between the Association and the affiliated Societies, and the extension of affiliation to other Societies who are at present excluded under Regulation 1.

This Resolution, having been referred to a COMMITTEE, consisting of Dr. E. H. Griffiths, Sir Norman Lockyer, Professor Meldola, Mr. F. W. Rudler, Mr. W. Whitaker, and the General Officers, to consider and report thereon to the Council, the Committee made the following recommendations :—

I. (i) 'That any Society which undertakes local scientific investigation and publishes the results may become a Society *affiliated* to the British Association.

(ii) 'That the Delegates of such Societies shall be members of the General Committee.

(iii) 'That any Society formed for the purpose of encouraging the study of science, which has existed for three years and numbers not fewer than fifty members, may become a Society *associated* with the British Association.

(iv) 'That all associated Societies shall have the right to appoint a Delegate to attend the Annual Conference, and that such Delegates shall have all the rights of those appointed by the affiliated Societies, except that of membership of the General Committee.'

II. The Committee further recommend that the Council request the Corresponding Societies Committee—

(i) 'To collect information as to the Societies of the United Kingdom who might become Associated Societies under Rule I.

(ii) 'To consider and report on the question of "A Journal of Corresponding Societies" referred to in Principal Griffith's Report.'

III. The Committee also recommend—

'That the Council, in nominating a Chairman of the Conference of Delegates, should choose one of their own body.'

On the recommendation of the CORRESPONDING SOCIETIES COMMITTEE, the following RESOLUTION, remitted to the Committee and embodying subsequent amendments, has been adopted by the Council :—

BY-LAW.

I. (i) 'That any Society which undertakes local scientific investigation and publishes the results may become a Society *affiliated* to the British Association.

(ii) 'That the Delegates of such Societies, who must be or become members of the British Association, shall be *ex officio* members of the General Committee.

(iii) 'That any Society formed for the purpose of encouraging the study of science, which has existed for three years and numbers not fewer than fifty members, may become a Society *associated* with the British Association.

(iv) 'That all associated Societies shall have the right to appoint a Delegate to attend the Annual Conference, and that such Delegates shall be members or associates of the British Association, and shall have all the rights of those appointed by the affiliated Societies, except that of membership of the General Committee.

II. 'That the Corresponding Societies Committee be requested to collect information as to the Societies of the United Kingdom who might become Associated Societies under Rule I. (*Corresponding Societies*).

III. 'That in nominating a Chairman of the Conference of Delegates, Rule VIII. (*Corresponding Societies*) be allowed to stand.'

VII. A Report has been received from the Corresponding Societies Committee, together with the list of the Corresponding Societies and the titles of the more important papers, especially of those referring to Local Scientific Investigations, published by the Societies during the year ending May 31, 1905.

VIII. A COMMITTEE of the Council, consisting of Dr. J. Scott Keltie, Professor Meldola, Professor W. W. Watts, and the General Officers, having been appointed to consider and report upon the following RESOLUTION :—

(i) 'That it is desirable that the Reports of Committees, especially where they extend over two or more years, should be offered for public circulation in a separate form from the annual volume of Reports, at a small price, say 6*d*. per copy.

(ii) 'That as there has been a great demand for copies of the Reports of the Women's Labour Committee of this Section, and it has been impossible to satisfy it, these Reports be printed and sold separately at the smallest charge possible.'

The COMMITTEE reported as follows :—

(i) 'As it is the custom of the Council to provide Committees with any reasonable number of separate copies of the Reports that are asked for while the type is standing, and as separate copies of such Reports are kept on sale and advertised in the Annual Volume, this Committee is of opinion that it is unnecessary to make any further arrangements for the separate publication of such Reports. The Committee are of opinion that any exceptional cases that arise might be dealt with by the General Officers, and subsequently reported to the Council.

'With regard to (ii) the Committee beg leave to recommend that it be left to the General Officers to communicate further with the Committee of Section F with a view to obtaining further information as to what is the demand for the Reports referred to, and to act at their discretion.'

IX. With reference to the nomination of two Members of Council for election by the GENERAL COMMITTEE, the Council has adopted the following Resolution :—

(i) A nomination for either of the two vacant seats on the Council may be made in writing by any two or more members of the General Committee, and must be sent to the Assistant Secretary so as to be received by him

at least twenty-four hours before the Meeting of the General Committee at which the election takes place.

(ii) The nominations shall be read to the Meeting by the Chairman; and if more than two persons be nominated, the election shall be by ballot or show of hands, and the two having the highest numbers of votes shall be declared elected.

(iii) In case no nomination, or only one nomination, shall be received, as provided for by By-law, two seats on the Council (or one seat, as the case may be) shall remain vacant until the next ensuing Meeting of the Council, when the seats (or seat, as the case may be) shall be filled by co-optation of the other members of the Council.

X. The following NOMINATIONS are made by the Council:—

(i) Dr. A. Smith Woodward, *Chairman*; Mr. W. Whitaker, *Vice-Chairman*; and Mr. F. W. Rudler, *Secretary*, of the CONFERENCE OF DELEGATES of Corresponding Societies to be held in London in October next.

(ii) Members of the CORRESPONDING SOCIETIES COMMITTEE for the ensuing year:—Mr. W. Whitaker (*Chairman*), Mr. F. W. Rudler (*Secretary*), Rev. J. O. Bevan, Dr. Horace T. Brown, Dr. Vaughan Cornish, Dr. J. G. Garson, Principal E. H. Griffiths, Mr. T. V. Holmes, Mr. J. Hopkinson, Professor R. Meldola, Dr. H. R. Mill, Mr. C. H. Read, Rev. T. R. R. Stebbing, Professor W. W. Watts, and the General Officers of the Association.

(iii) SECTIONAL OFFICERS for the Meeting in South Africa, whose names appear on the printed programme.

XI. The Council has received reports from the General Treasurer during the past year, and his ACCOUNTS from July 1, 1904, to June 30, 1905, have been audited and are presented to the General Committee.

XII. In accordance with the regulations, the retiring Members of the COUNCIL are as follows:—By *seniority*, Professor H. E. Armstrong, Dr. J. Bonar, and Major L. Darwin; by *least attendance*, Sir W. Abney, and Mr. H. J. Mackinder.

The Council recommend the re-election of the other ordinary Members of the Council, with the addition of the gentlemen whose names are distinguished by an asterisk in the following list:—

Bourne, G. C., D.Sc.
Bower, Professor F. O., F.R.S.
Brabrook, E. W., C.B.
Brown, Dr. Horace T., F.R.S.
Callendar, Professor H. L., F.R.S.
Cunningham, Professor D. J., F.R.S.
*Dunstan, W. R., F.R.S.
*Dyson, F. W., F.R.S.
*Glazebrook, Dr. R. T., F.R.S.
Gotch, Professor F., F.R.S.
Haddon, Dr. A. C., F.R.S.
Hawksley, C., M.Inst.C.E.
Higgs, Henry, LL.B.
Langley, Professor J. N., F.R.S.
Macalister, Professor A., F.R.S.
McKendrick, Professor J. G., F.R.S.
Noble, Sir A., Bart., K.C.B., F.R.S.
Perkin, Professor W. H., F.R.S.
Seward, A. C., F.R.S.
Shaw, Dr. W. N., F.R.S.
Shipley, A. E., F.R.S.
Watts, Professor W. W., F.R.S.
Woodward, Dr. A. Smith, F.R.S.

XIII. The following claims for admission to the GENERAL COMMITTEE have been allowed by the Council:—

Mr. Arnold T. Watson.
Mr. John Bolton.

Committees appointed by the General Committee at the South African Meeting in August and September, 1905.

1. *Receiving Grants of Money.*

Subject for Investigation or Purpose	Members of the Committee	Grants
	Section A.—MATHEMATICS AND PHYSICS.	£ s. d.
Making Experiments for improving the Construction of Practical Standards for use in Electrical Measurements.	*Chairman.*—Lord Rayleigh. *Secretary.*—Dr. R. T. Glazebrook. Lord Kelvin, Professors W. E. Ayrton, J. Perry, W. G. Adams, and G. Carey Foster, Sir Oliver Lodge, Dr. A. Muirhead, Sir W. H. Preece, Professor A. Schuster, Dr. J. A. Fleming, Professor J. J. Thomson, Dr. W. N. Shaw, Dr. J. T. Bottomley, Rev. T. C. Fitzpatrick, Dr. G. Johnstone Stoney, Professor S. P. Thompson, Mr. J. Rennie, Principal E. H. Griffiths, Sir A. W. Rücker, Professor H. L. Callendar, and Mr. G. Matthey.	25 0 0 and unexpended balance.
Seismological Observations.	*Chairman.*—Professor J. W. Judd. *Secretary.*—Mr. J. Milne. Lord Kelvin, Dr. T. G. Bonney, Mr. C. V. Boys, Professor G. H. Darwin, Mr. Horace Darwin, Major L. Darwin, Professor J. A. Ewing, Mr. M. H. Gray, Dr. R. T. Glazebrook, Professor C. G. Knott, Professor R. Meldola, Mr. R. D. Oldham, Professor J. Perry, Mr. W. E. Plummer, Professor J. H. Poynting, Mr. Clement Reid, Mr. Nelson Richardson, and Professor H. H. Turner.	40 0 0
To co-operate with the Committee of the Falmouth Observatory in their Magnetic Observations.	*Chairman.*—Sir W. H. Preece. *Secretary.*—Dr. R. T. Glazebrook. Professor W. G. Adams, Captain Creak, Mr. W. L. Fox, Professor A. Schuster, Sir A. W. Rücker, and Dr. Charles Chree.	50 0 0
To continue the Magnetic Survey of South Africa commenced by Professors Beattie and Morrison.	*Chairman.*—Sir David Gill. *Secretary.*—Professor J. C. Beattie. Mr. S. S. Hough, Professor Morrison, and Professor A. Schuster.	100 0 0

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants
Section B.—CHEMISTRY.		
		£ s. d.
Preparing a new Series of Wave-length Tables of the Spectra of the Elements.	*Chairman.*—Sir H. E. Roscoe. *Secretary.*—Dr. Marshall Watts. Sir Norman Lockyer, Professors Sir J. Dewar, G. D. Liveing, A. Schuster, W. N. Hartley, and Wolcott Gibbs, Sir W. de W. Abney, and Dr. W. E. Adeney.	5 0 0
The Study of Hydro-aromatic Substances.	*Chairman.*—Professor E. Divers. *Secretary.*—Dr. A. W. Crossley. Professor W. H. Perkin, Dr. M. O. Forster, and Dr. Le Sueur.	25 0 0
The Transformation of Aromatic Nitramines and allied substances, and its relation to Substitution in Benzene Derivatives.	*Chairman.*—Professor F. S. Kipping. *Secretary.*—Professor K. J. P. Orton. Dr. S. Ruhemann, Dr. A. Lapworth, and Dr. J. T. Hewitt.	10 0 0
Section C.—GEOLOGY.		
To investigate the Erratic Blocks of the British Isles, and to take measures for their preservation.	*Chairman.*—Dr. J. E. Marr. *Secretary.*—Mr. P. F. Kendall. Dr. T. G. Bonney, Mr. C. E. De Rance, Professor W. J. Sollas, Mr. R. H. Tiddeman, Rev. S. N. Harrison, Dr. J. Horne, Mr. F. M. Burton, Mr. J. Lomas, Mr. A. R. Dwerryhouse, Mr. J. W. Stather, Mr. W. T. Tucker, and Mr. F. W. Harmer.	Unexpended balance.
To study Life-zones in the British Carboniferous Rocks.	*Chairman.*—Dr. J. E. Marr. *Secretary.*—Dr. Wheelton Hind. Dr. F. A. Bather, Mr. G. C. Crick, Mr. A. H. Foord, Mr. H. Fox, Professor E. J. Garwood, Dr. G. J. Hinde, Professor P. F. Kendall, Mr. R. Kidston, Mr. G. W. Lamplugh, Professor G. A. Lebour, Mr. B. N. Peach, Mr. A. Strahan, Mr. D. T Gwynne Vaughan, and Dr. H. Woodward.	Balance in hand.
To report upon the Fauna and Flora of the Trias of the British Isles.	*Chairman.*—Professor W. A. Herdman. *Secretary.*—Mr. J. Lomas. Professors W. W. Watts and P. F. Kendall, Messrs. H. C. Beasley, E. T. Newton, A. C. Seward, and W. A. E. Ussher, and Dr. A. Smith Woodward.	7 8 11 and unexpended balance.

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants
		£ s. d.
To investigate the Fossiliferous Drift Deposits at Kirmington, Lincolnshire, and at various localities in the East Riding of Yorkshire.	*Chairman.*—Mr. G. W. Lamplugh. *Secretary.*—Mr. J. W. Stather. Dr. Tempest Anderson, Professor J. W. Carr, Rev. W. Lower Carter, Messrs. A. R. Dwerryhouse, F. W. Harmer, and J. H. Howarth, Rev. W. Johnson, and Messrs. P. F. Kendall, E. T. Newton, H. M. Platnauer, Clement Reid, and T. Sheppard.	Balance in hand.
To enable Mr. E. Greenly to complete his Researches on the Composition and Origin of the Crystalline Rocks of Anglesey.	*Chairman.*—Mr. A. Harker. *Secretary.*—Mr. E. Greenly. Mr. J. Lomas and Dr. C. A. Matley.	30 0 0
To enable Dr. A. Vaughan to continue his Researches on the Faunal Succession in the Carboniferous Limestone of the South-west of England.	*Chairman.*—Professor J. W. Gregory. *Secretary.*—Dr. A. Vaughan. Dr. Wheelton Hind and Professor W. W. Watts.	15 0 0
To investigate and report on the Correlation and Age of South African Strata and on the question of a Uniform Stratigraphical Nomenclature.	*Chairman.*—Professor J. W. Gregory. *Secretary.*—Professor A. Young. Mr. W. Anderson, Professor R. Broom, Dr. G. S. Corstorphine, Mr. Walcot Gibson, Dr. F. H. Hatch, Mr. T. H. Holland, Mr. H. Kynaston, Dr. Molengraaf, Mr. A. W. Rogers, Mr. E. H. L. Schwarz, and Professor R. B. Young.	10 0 0
	SECTION D.—ZOOLOGY.	
To aid competent Investigators selected by the Committee to carry on definite pieces of work at the Zoological Station at Naples.	*Chairman.*—Professor S. J. Hickson. *Secretary.*—Rev. T. R. R. Stebbing. Professor E. Ray Lankester, Professor W. F. R. Weldon, Mr. A. Sedgwick, Professor W. C. McIntosh, and Mr. G. P. Bidder.	100 0 0
Compilation of an Index Generum et Specierum Animalium.	*Chairman.*—Dr. H. Woodward. *Secretary.*—Dr. F. A. Bather. Dr. P. L. Sclater, Rev. T. R. R. Stebbing, Mr. W. E. Hoyle, the Hon. Walter Rothschild, and Lord Walsingham.	75 0 0
To enable Mr. J. W. Jenkinson to continue his Researches on the Influence of Salt and other Solutions on the Development of the Frog.	*Chairman.*—Professor Weldon. *Secretary.*—Mr. J. W. Jenkinson. Professor S. J. Hickson.	10 0 0
To enable Dr. F. W. Gamble and Mr. F. W. Keeble to conduct Researches on the relation between Respiratory Phenomena and Colour Changes in the Higher Crustacea.	*Chairman.*—Professor S. J. Hickson. *Secretary.*—Dr. F. W. Gamble. Dr. Hoyle and Mr. F. W. Keeble.	15 0 0

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants
		£ s. d.
The Freshwater Fishes of South Africa, with special reference to those of the Zambesi.	*Chairman.*—Mr. G. A. Boulenger. *Secretary.*—Dr. J. D. F. Gilchrist. Mr. W. L. Sclater.	50 0 0

Section E.—GEOGRAPHY.

Subject for Investigation or Purpose	Members of the Committee	Grants
The Quantity and Composition of Rainfall, and of Lake and River Discharge.	*Chairman.*—Sir John Murray. *Secretaries.*—Professor A. B. Macallum and Dr. A. J. Herbertson. Sir B. Baker, Professor W. M. Davis, Professor P. F. Frankland, Mr. A. D. Hall, Mr. E. H. V. Melville, Dr. H. R. Mill, Professor A. Penck, and Mr. W. Whitaker.	10 0 0

Section F.—ECONOMIC SCIENCE AND STATISTICS.

Subject for Investigation or Purpose	Members of the Committee	Grants
The Accuracy and Comparability of British and Foreign Statistics of International Trade.	*Chairman.*—Dr. E. Cannan. *Secretary.*—Mr. W. G. S. Adams. Mr. A. L. Bowley, Professor S. J. Chapman, and Sir R. Giffen.	20 0 0

Section H.—ANTHROPOLOGY.

Subject for Investigation or Purpose	Members of the Committee	Grants
To conduct Archæological and Ethnological Researches in Crete.	*Chairman.*—Sir John Evans. *Secretary.*—Mr. J. L. Myres. Mr. R. C. Bosanquet, Mr. A. J. Evans, Mr. D. G. Hogarth, Professor A. Macalister, and Professor W. Ridgeway.	100 0 0
To investigate the Lake Village at Glastonbury, and to report on the best method of publication of the result.	*Chairman.*—Dr. R. Munro. *Secretary.*—Professor W. Boyd Dawkins. Sir John Evans and Messrs. Arthur J. Evans, C. H. Read, H. Balfour, and A. Bulleid.	40 0 0
To co-operate with Local Committees in Excavations on Roman Sites in Britain.	*Chairman.*—Professor W. Boyd Dawkins. *Secretary.*—Mr. J. L. Myres. Sir E. W. Brabrook, Mr. T. Ashby, and Professor W. Ridgeway.	30 0 0
To organise Anthropometric Investigation in the British Isles.	*Chairman.*—Professor D. J. Cunningham. *Secretary.*—Mr. J. Gray. Dr. A. C. Haddon, Dr. C. S. Myers, Mr. J. L. Myres, Professor A. F. Dixon, Mr. E. N. Fallaize, Mr. Randall-MacIver, Professor J. Symington, Dr. Waterston, Sir E. W. Brabrook, Dr. T. H. Bryce, Mr. W. H. L. Duckworth, Mr. G. L. Gomme, Major T. McCulloch, Dr. F. C. Shrubsall, Professor G. D. Thane, and Mr. J. F. Tocher.	30 0 0

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants
To conduct Explorations with the object of ascertaining the Age of Stone Circles.	*Chairman.*—Mr. C. H. Read. *Secretary.*—Mr. H. Balfour. Sir John Evans, Dr. J. G. Garson, Mr. A. J. Evans, Dr. R. Munro, Professor Boyd Dawkins, and Mr. A. L. Lewis.	£ s. d. Balance in hand.

Section I.—PHYSIOLOGY.

The State of Solution of Proteids.	*Chairman.*—Professor W. D. Halliburton. *Secretary.*—Professor E. Waymouth Reid. Professor E. A. Schäfer.	20 0 0
To enable Professor Starling, Professor Brodie, Dr. Hopkins, Mr. Fletcher, Mr. Barcroft, and others to determine the 'Metabolic Balance Sheet' of the Individual Tissues.	*Chairman.*—Professor Gotch. *Secretary.*—Mr. J. Barcroft Sir Michael Foster and Professor Starling.	20 0 0 and unexpended balance.
The Ductless Glands.	*Chairman.*—Professor Schäfer. *Secretary.*—Professor Swale Vincent. Professor A. B. Macallum, Dr. L. E. Shore and Mr. J. Barcroft.	10 0 0
The Effect of Climate upon Health and Disease.	*Chairman.*—Sir T. Lauder Brunton. *Secretary.*—Mr. J. Barcroft. Colonel D. Bruce, Dr. A. Buchan, Dr. F. Campbell, Sir Kendal Franks, Professor J. G. McKendrick, Sir A. Mitchell, Dr. W. C. F. Murray, Dr. Porter, Professor G. Sims Woodhead, Dr. A. J. Wright, and the Heads of the Tropical Schools of Liverpool and London.	20 0 0

Section K.—BOTANY.

To carry out the scheme for the Registration of Negatives of Botanical Photographs.	*Chairman.*—Professor L. C. Miall. *Secretary.*—Professor F. E. Weiss. Mr. Francis Darwin, Dr. W. G. Smith, Mr. A. G. Tansley, and Professor R. H. Yapp.	3 0 0
Experimental Studies in the Physiology of Heredity.	*Chairman.*—Professor H. Marshall Ward. *Secretary.*—Mr. H. Wager. Mr. Francis Darwin and Professor J. B. Farmer.	30 0 0

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants £ s. d.
The Structure of Fossil Plants.	*Chairman.*—Dr. D. H. Scott. *Secretary.*—Professor F.W. Oliver Messrs. E. Newell Arber and A. C. Seward and Professor F. E. Weiss.	20 0 0
Research on South African Cycads.	*Chairman.*—Mr. A. C. Seward. *Secretary.*—Mr. R. P. Gregory. Dr. D. H. Scott and Dr. W. H. Lang.	50 0 0
The Peat Moss Deposits in the Cross Fell, Caithness, and Isle of Man Districts.	*Chairman.*—Professor R.J.Harvey Gibson. *Secretary.*—Professor R. H. Yapp. Professor J. R. Green and Mr. Clement Reid.	25 0 0

Section L.—EDUCATIONAL SCIENCE.

To report upon the Course of Experimental, Observational, and Practical Studies most suitable for Elementary Schools.	*Chairman.*—Sir Philip Magnus. *Secretary.*—Mr. W. M. Heller. Sir W. de W. Abney, Mr. R. H. Adie, Professor H. E. Armstrong, Miss A. J. Cooper, Miss L. J. Clarke, Mr. George Fletcher, Professor R. A. Gregory, Principal Griffiths, Mr. A. D. Hall, Dr. A. J. Herbertson, Dr. C. W. Kimmins, Professor J. Perry, Mrs. W. N. Shaw, Professor A. Smithells, Dr. Lloyd Snape, Principal Reichel, Mr. H. Richardson, Mr. Harold Wager, Miss Edna Walter, and Professor W. W. Watts.	20 0 0
The Conditions of Health essential to the carrying on of the work of instruction in schools.	*Chairman.*—Professor Sherrington. *Secretary.*—Mr. E. White Wallis. Sir E. W. Brabrook, Dr. C. W. Kimmins, Professor L. C. Miall, and Miss Maitland.	2 0 0
To consider and report upon the Influence exercised by Universities and Examining Bodies on secondary school curricula, and also of the schools on university requirements.	*Chairman.*—Dr. H. E. Armstrong. *Secretary.*—Mr. R. A. Gregory. The Bishop of Hereford, Sir Michael Foster, Sir P. Magnus, Sir A. W. Rücker, Sir O. J. Lodge, Mr. H.W. Eve, Mr. W. A. Shenstone, Mr. W. D. Eggar, Professor Marshall Ward, Mr. F. H. Neville, Mrs. W. N. Shaw, and Dr. C. W. Kimmins.	5 0 0

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants
CORRESPONDING SOCIETIES.		
Corresponding Societies Committee for the preparation of their Report.	*Chairman.*—Mr. W. Whitaker. *Secretary.*—Mr. F. W. Rudler. Rev. J. O. Bevan, Dr. H. T. Brown, Dr. Vaughan Cornish, Dr. J. G. Garson, Principal E. H. Griffiths, Mr. T. V. Holmes, Mr. J. Hopkinson, Professor R. Meldola, Dr. H. R. Mill, Mr. C. H. Read, Rev. T. R. R. Stebbing, Prof. W. W. Watts, and the General Officers of the Association.	£ s. d. 25 0 0

2. *Not receiving Grants of Money.*

Subject for Investigation or Purpose	Members of the Committee
SECTION A.—MATHEMATICS AND PHYSICS.	
To co-operate with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis.	*Chairman.*—Lord McLaren. *Secretary.*—Professor Crum Brown. Sir John Murray, Dr. A. Buchan, Professor R. Copeland, and Mr. Omond.
The Rate of Increase of Underground Temperature downwards in various Localities of Dry Land and under Water.	*Chairman* and *Secretary.*—Professor H. L. Callendar. Lord Kelvin, Sir Archibald Geikie, Professor Edward Hull, Professor A. S. Herschel, Professor G. A. Lebour, Dr. C. H. Lees, Mr. A. B. Wynne, Mr. W. Galloway, Mr. Joseph Dickinson, Mr. G. F. Deacon, Mr. Edward Wethered, Mr. A. Strahan, Professor Michie Smith, and Mr. B. H. Brough.
The Consideration of the Teaching of Elementary Mechanics, and the Improvement which might be effected in such Teaching.	*Chairman.*—Professor Horace Lamb. *Secretary.*—Professor J. Perry. Mr. C. Vernon Boys, Professors Chrystal, Ewing, G. A. Gibson, and Greenhill, Principal Griffiths, Professor Henrici, Dr. E. W. Hobson, Mr. C. S. Jackson, Sir Oliver Lodge, Professors Love, Minchin, and Schuster, and Mr. A. W. Siddons.

2. *Not receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee
To co-operate with the Royal Meteorological Society in the Investigation of the Upper Atmosphere by means of Kites.	*Chairman.*—Dr. W. N. Shaw. *Secretary.*—Mr. W. H. Dines. Mr. D. Archibald, Mr. C. Vernon Boys, Dr. A. Buchan, Dr. R. T. Glazebrook, Dr. H. R. Mill, Dr. A. Schuster, and Dr. W. Watson.
That Miss Hardcastle be requested to continue her Report on the present state of the Theory of Point-groups.	

Section B.—CHEMISTRY.

Isomeric Naphthalene Derivatives.	*Chairman.*—Professor W. A. Tilden. *Secretary.*—Professor H. E. Armstrong.
The Study of Isomorphous Sulphonic Derivatives of Benzene.	*Chairman.*—Professor H. A. Miers. *Secretary.*—Professor H. E. Armstrong. Dr. W. P. Wynne and Professor W. J. Pope.
Dynamic Isomerism.	*Chairman.*—Professor H. E. Armstrong. *Secretary.*—Dr. T. M. Lowry. Professor Sydney Young, Dr. J. J. Dobbie, Dr. A. Lapworth, and Dr. M. O. Forster.

Section C.—GEOLOGY.

The Collection, Preservation, and Systematic Registration of Photographs of Geological Interest.	*Chairman.*—Professor J. Geikie. *Secretary.*—Professor W. W. Watts. Dr. T. G. Bonney, Dr. T. Anderson, Professors E. J. Garwood and S. H. Reynolds, and Messrs. A. S. Reid, W. Gray, H. B. Woodward, R. Kidston, J. J. H. Teall, J. G. Goodchild, H. Coates, C. V. Crook, G. Bingley, R. Welch, and W. J. Harrison.
To record and determine the Exact Significance of Local Terms applied in the British Isles to Topographical and Geological Objects.	*Chairman.*—Mr. Douglas W. Freshfield. *Secretary.*—Mr. W. G. Fearnsides. Lord Avebury, Mr. C. T. Clough, Professor E. J. Garwood, Mr. E. Heawood, Dr. A. J. Herbertson, Col. D. A. Johnston, Mr. O. T. Jones, Dr. J. S. Keltie, Mr. G. W. Lamplugh, Mr. H. J. Mackinder, Dr. E. J. Marr, Dr. H. R. Mill, Mr. H. Yule Oldham, Dr. B. N. Peach, Professor W. W. Watts, and Mr. H. B. Woodward.
To enable Mr. T. Leslie to continue his researches into the Fossil Flora of the Transvaal.	*Chairman.*—Professor J. W. Gregory. *Secretary.*—Mr. A. C. Seward. Mr. T. N. Leslie.

2. *Not receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee
SECTION D.—ZOOLOGY.	
To continue the Investigation of the Zoology of the Sandwich Islands, with power to co-operate with the Committee appointed for the purpose by the Royal Society, and to avail themselves of such assistance in their investigations as may be offered by the Hawaiian Government or the Trustees of the Museum at Honolulu. The Committee to have power to dispose of specimens where advisable.	*Chairman.*—Professor A. Newton. *Secretary.*—Dr. David Sharp. Dr. W. T. Blanford, Professor S. J. Hickson, Dr. P. L. Sclater, Mr. F. Du Cane Godman, and Mr. Edgar A. Smith.
To conduct an Investigation into the Madreporaria of the Bermuda Islands.	*Chairman.*—Professor S. J. Hickson. *Secretary.*—Dr. W. E. Hoyle. Dr. F. F. Blackman, Mr. J. S. Gardiner, Professor W. A. Herdman, Mr. A. C. Seward, Professor C. S. Sherrington, and Mr. A. G. Tansley.
To summon meetings in London or elsewhere for the consideration of matters affecting the interests of Zoology or Zoologists, and to obtain by correspondence the opinion of Zoologists on matters of a similar kind, with power to raise by subscription from each Zoologist a sum of money for defraying current expenses of the Organisation.	*Chairman.*—Professor E. Ray Lankester. *Secretary.*—Professor S. J. Hickson. Professors T. W. Bridge, J. Cossar Ewart, M. Hartog, W. A. Herdman, and J. Graham Kerr, Mr. O. H. Latter, Professor Minchin, Dr. P. C. Mitchell, Professor C. Lloyd Morgan, Professor E. B. Poulton, Mr. A. Sedgwick, Mr. A. E. Shipley, and Rev. T. R. R. Stebbing.
To inquire into the probability of *Ankylostoma* becoming a permanent inhabitant of our coal mines in the event of its introduction, with power to issue an interim report.	*Chairman.*—Mr. A. E. Shipley. *Secretary.*—Mr. G. P. Bidder. Mr. G. H. F. Nuttall.
To enable Miss Igerna Sollas, of Newnham College, Cambridge, to study certain points in the development of Ophiusoids, and to enable other competent naturalists to perform definite pieces of work at the Marine Laboratory, Plymouth.	*Chairman* and *Secretary.*—Mr. W. Garstang. Professor E. Ray Lankester, Mr. A. Sedgwick, Professor Sydney H. Vines, and Professor W. F. R. Weldon.
To enable Dr. H. W. Marett Tims to conduct experiments with regard to the effect of the Sera and Antisera on the Development of the Sexual Cells.	*Chairman.*—Mr. G. H. F. Nuttall. *Secretary.*—Dr. H. W. Marett Tims. Mr. J. Stanley Gardiner.
SECTION E.—GEOGRAPHY.	
The continued Investigation of the Oscillations of the Level of the Land in the Mediterranean Basin.	*Chairman.*—Mr. D. G. Hogarth. *Secretary.*—Mr. R. T. Günther. Drs. T. G. Bonney, F. H. Guillemard, J. S. Keltie, and H. R. Mill.

2. *Not receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee
To carry on an Expedition to investigate the Indian Ocean between India and South Africa in view of a possible land connection, to examine the deep submerged banks, the Nazareth and Saza de Malha, and also the distribution of Marine Animals.	*Chairman.*—Sir John Murray. *Secretary.*—Mr. J. Stanley Gardiner. Dr. W. T. Blandford, Captain E. W. Creak, Professors W. A. Herdman, S. J. Hickson, and J. W. Judd, Mr. J. J. Lister, and Dr. H. R. Mill.

Section G.—ENGINEERING.

To investigate the Resistance of Road Vehicles to Traction.	*Chairman.*—Sir J. I. Thornycroft. *Secretary.*—Mr. A. Mallock. Mr. T. Aitken, Mr. T. C. Aveling, Professor T. Hudson Beare, Mr. W. W. Beaumont, Mr. J. Brown, Colonel R. E. Crompton, Mr. B. J. Diplock, Professor J. Perry, Sir D. Salomons, Mr. A. R. Sennett, Mr. E. Shrapnell Smith, and Professor W. C. Unwin.
To consider the Incidence of the Patent and Design Laws upon the National Development of the Practical Applications of Science.	*Chairman.*—Sir W. H. Preece. *Secretary.*—Sir H. Trueman Wood. Mr. C. D. Abel, Mr. Dugald Clerk, Dr. R. T. Glazebrook, Mr. R. A. Hadfield, Hon. C. A. Parsons, and Mr. A. Siemens.

Section H.—ANTHROPOLOGY.

The Collection, Preservation, and Systematic Registration of Photographs of Anthropological Interest.	*Chairman.*—Mr. C. H. Read. *Secretary.*—Mr. H. S. Kingsford. Dr. J. G. Garson, Mr. H. Ling Roth, Mr. H. Balfour, Dr. A. C. Haddon, Mr. E. S. Hartland, Mr. E. Heawood, Professor Flinders Petrie, Mr. E. N. Fallaize, and Mr. J. L. Myres.
To consider what steps may be taken to organise Anthropological Teaching and Research in the British Empire.	*Chairman.*—Professor E. B. Tylor. *Secretary.*—Mr. J. L. Myres. Mr. H. Balfour, Professor D. J. Cunningham, Mr. G. L. Gomme, Dr. A. C. Haddon, Professor A. Macalister, Dr. C. S. Myers, Professor Flinders Petrie, Mr. C. H. Read, and Mr. F. W. Rudler.
To conduct Anthropometric Investigations among the Native Troops of the Egyptian Army.	*Chairman.*—Professor A. Macalister. *Secretary.*—Dr. C. S. Myers. Sir John Evans and Professor D. J. Cunningham.

2. *Not receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee
Section L.—EDUCATIONAL SCIENCE.	
The Training of Teachers.	*Chairman.*—The Bishop of Hereford. *Secretary.*—Mr. J. L. Holland. Professor H. E. Armstrong, Mr. Oscar Browning, Miss A. J. Cooper, Mr. Ernest Gray, and Dr. H. B. Gray.

Communications ordered to be printed in extenso.

The Geodetic Survey of South Africa. By Sir David Gill.
On Star Streaming. By Professor Kapteyn.
The Apioidal Binary Star Systems. By Dr. A. W. Roberts.
Some Recent Developments in Agricultural Science. By A. D. Hall.
Habits and Peculiarities of some South African Ticks. By C. P. Lounsbury.
The lectures of Mr. Lamplugh and Mr. Randall-MacIver (or abstracts thereof).

Resolutions referred to the Council for consideration, and action if desirable.

That the Council be requested to consider whether it is desirable that arrangements should be made for the separate publication of individual papers, and in particular that they be asked to consider the advisability of publishing a selection of papers having special reference to South Africa.

From Section A.

(i.) The Committee, being of opinion that the completion of the Geodetic Arc from the South to the North of Africa is of the utmost scientific importance, and that the establishment of a Topographical Survey is of an importance that is at once scientific and economic, respectfully request the Council to make representations in such form as they think fit to urge upon the British South African Company the desirability of taking advantage of the present favourable opportunity for joining up the triangulation north and south of the Zambesi, and also to urge upon the Governments of the South African Colonies the immense practical and economic importance of commencing the topographical survey.

(ii.) The Committee desire to draw attention to the importance of a Magnetic Survey of South Africa, and respectfully request the Council of the Association to approach the Cape Government with a view to urging on them the great advantages which would accrue to Science and to South Africa if the Government would further support and assist the Survey which has already been partly made by Professor Beattie and Professor Morrison, and for the continuation of which a special Committee of the Association is being appointed to co-operate with these gentlemen.

From Section H.

(i.) That it is desirable that the Governments of the South African Colonies be urged to take all necessary steps to collect, record, and preserve the knowledge and observations of men, such as missionaries, administrators, and others, who were living in intimate relations with the native tribes before the advance of civilisation began to obscure and even obliterate all true traditions, customs, and habits of the

South African peoples; such steps to be taken without delay, especially in view of the old age and growing infirmities of most of the men referred to, and of the danger that with their deaths the knowledge, which if carefully recorded and preserved would form a most valuable contribution towards the history of the aboriginal population, would be irrevocably lost; and that the Council be recommended to communicate with the South African Association and suggest the appointment of a Committee to deal with the matter.

(ii.) That, owing to the use by different writers and Government authorities of various names for the same groups of South African natives, much confusion and difficulty have arisen in anthropological and historical literature; that it is consequently desirable that Government authorities and others should confer as to the proper nomenclature of such groups (clans, tribes, and nations), with a view to ascertaining their interrelationships, and to suggesting the most appropriate name for each group, and the best method of spelling that name phonetically; and that the Council be recommended to communicate with the South African Association and take such other steps as may conduce to this object.

(iii.) That the Committee are of opinion that it would conduce to the greater efficiency of officers who have to administer native affairs, and contribute to the advancement of anthropological science, as well as prove of considerable advantage to the well-being of the natives themselves, if opportunity could be given to such officers before or after their appointment to study comparative ethnology for at least two terms in one of the Universities of the United Kingdom which presents facilities for the study; and that in the case of junior officers already on active service such a course of study would facilitate their comprehension of native institutions and ideas and help to render their services more efficient; another Committee recommends the Council to take steps for the purpose of bringing this matter before the proper authorities.

Synopsis of Grants of Money appropriated to Scientific Purposes by the General Committee at the South Africa Meeting, August and September 1905. The Names of the Members entitled to call on the General Treasurer for the respective Grants are prefixed.

	£	s.	d.
Mathematical and Physical Science.			
*Rayleigh, Lord—Electrical Standards (and unexpended balance)	25	0	0
*Judd, Professor J. W.—Seismological Observations	40	0	0
*Preece, Sir W. H.—Magnetic Observations at Falmouth	50	0	0
Gill, Sir D.—Magnetic Survey of South Africa	100	0	0
Chemistry.			
*Roscoe, Sir H. E.—Wave-length Tables of Spectra	5	0	0
*Divers, Professor E.—Study of Hydro-Aromatic Substances	25	0	0
*Kipping, Professor F. S.—Aromatic Nitramines	10	0	0
Geology.			
*Marr, Dr. J. E.—Erratic Blocks (unexpended balance)		—	
*Marr, Dr. J. E.—Life-zones in British Carboniferous Rocks (unexpended balance)		—	
*Herdman, Professor W. A.—Fauna and Flora of British Trias (and unexpended balance)	7	8	11
*Lamplugh, G. W.—Fossiliferous Drift Deposits (balance in hand)		—	
Harker, Dr. A.—The Crystalline Rocks of Anglesey	30	0	0
Gregory, Professor J. W.—Faunal Succession in the Carboniferous Limestone of the South-west of England	15	0	0
Gregory, Professor J. W.—The Correlation and Age of South African Strata, &c.	10	0	0
Zoology.			
*Hickson, Professor S. J.—Table at the Zoological Station at Naples	100	0	0
*Woodward, Dr. H.—Index Animalium	75	0	0
*Weldon, Professor—Development of the Frog	10	0	0
*Hickson, Professor S. J.—Higher Crustacea	15	0	0
Boulenger, G. A.—Freshwater Fishes of South Africa	50	0	0
Geography.			
Murray, Sir J.—Rainfall and Lake and River Discharge	10	0	0
Economic Science and Statistics.			
*Cannan, Dr. E.—British and Foreign Statistics of International Trade	20	0	0
Carried forward	£597	8	11

* Reappointed.

	£	s.	d.
Brought forward	597	8	11
Anthropology.			
*Evans, Sir J.—Excavations in Crete	100	0	0
*Munro, Dr. R.—Lake Village at Glastonbury	40	0	0
*Dawkins, Professor W. Boyd.—Excavations on Roman Sites in Britain	30	0	0
*Cunningham, Professor D. J.—Anthropometric Investigation in the British Isles	30	0	0
*Reid, C. H.—Age of Stone Circles (balance in hand)		—	
Physiology.			
*Halliburton, Professor W. D.—The State of Solution of Proteids	20	0	0
*Gotch, Professor—Metabolism of Individual Tissues (and unexpended balance)	20	0	0
*Schäfer, Professor—The Ductless Glands	10	0	0
Brunton, Sir Lauder.—The Effect of Climate upon Health and Disease	20	0	0
Botany.			
*Miall, Professor—Botanical Photographs (and unexpended balance)	3	0	0
*Ward, Professor H. Marshall—The Physiology of Heredity	30	0	0
*Scott, Dr. D. H.—The Structure of Fossil Plants (and unexpended balance)	20	0	0
Seward, A. C.—Research on South African Cycades	50	0	0
Gibson, Professor Harvey.—Peat Moss Deposits	25	0	0
Educational Science.			
*Magnus, Sir P.—Studies suitable for Elementary Schools	20	0	0
*Sherrington, Professor.—Health in relation to School Instruction	2	0	0
*Armstrong, Professor H. E.—Universities and School Curricula	5	0	0
Corresponding Societies Committee.			
*Whitaker, W.—Preparing Report, &c.	25	0	0
	£1,047	8	11

* Reappointed.

The Annual Meeting in 1906.

The Annual Meeting of the Association in 1906 will be held at York, commencing August 1.

The Annual Meeting in 1907.

The Annual Meeting of the Association in 1907 will be held at Leicester.

General Statement of Sums which have been paid on account of Grants for Scientific Purposes.

1834.

	£	s.	d.
Tide Discussions	20	0	0

1835.

	£	s.	d.
Tide Discussions	62	0	0
British Fossil Ichthyology	105	0	0
	£167	0	0

1836.

	£	s.	d.
Tide Discussions	163	0	0
British Fossil Ichthyology	105	0	0
Thermometric Observations, &c.	50	0	0
Experiments on Long-continued Heat	17	1	0
Rain-gauges	9	13	0
Refraction Experiments	15	0	0
Lunar Nutation	60	0	0
Thermometers	15	6	0
	£435	0	0

1837.

	£	s.	d.
Tide Discussions	284	1	0
Chemical Constants	24	13	6
Lunar Nutation	70	0	0
Observations on Waves	100	12	0
Tides at Bristol	150	0	0
Meteorology and Subterranean Temperature	93	3	0
Vitrification Experiments	150	0	0
Heart Experiments	8	4	6
Barometric Observations	30	0	0
Barometers	11	18	6
	£922	12	6

1838.

	£	s.	d.
Tide Discussions	29	0	0
British Fossil Fishes	100	0	0
Meteorological Observations and Anemometer (construction)	100	0	0
Cast Iron (Strength of)	60	0	0
Animal and Vegetable Substances (Preservation of)	19	1	10
Railway Constants	41	12	10
Bristol Tides	50	0	0
Growth of Plants	75	0	0
Mud in Rivers	3	6	6
Education Committee	50	0	0
Heart Experiments	5	3	0
Land and Sea Level	267	8	7
Steam-vessels	100	0	0
Meteorological Committee	31	9	5
	£932	2	2

1839.

	£	s.	d.
Fossil Ichthyology	110	0	0
Meteorological Observations at Plymouth, &c.	63	10	0
Mechanism of Waves	144	2	0
Bristol Tides	35	18	6
Meteorology and Subterranean Temperature	21	11	0
Vitrification Experiments	9	4	0
Cast-iron Experiments	103	0	7
Railway Constants	28	7	0
Land and Sea Level	274	1	2
Steam-vessels' Engines	100	0	4
Stars in Histoire Céleste	171	18	0
Stars in Lacaille	11	0	6
Stars in R.A.S. Catalogue	166	16	0
Animal Secretions	10	10	6
Steam Engines in Cornwall	50	0	0
Atmospheric Air	16	1	0
Cast and Wrought Iron	40	0	0
Heat on Organic Bodies	3	0	0
Gases on Solar Spectrum	22	0	0
Hourly Meteorological Observations, Inverness and Kingussie	49	7	
Fossil Reptiles	118	2	9
Mining Statistics	50	0	0
	£1595	11	0

1840.

	£	s.	d.
Bristol Tides	100	0	0
Subterranean Temperature	13	13	6
Heart Experiments	18	19	0
Lungs Experiments	8	13	0
Tide Discussions	50	0	0
Land and Sea Level	6	11	1
Stars (Histoire Céleste)	242	10	0
Stars (Lacaille)	4	15	0
Stars (Catalogue)	264	0	0
Atmospheric Air	15	15	0
Water on Iron	10	0	0
Heat on Organic Bodies	7	0	0
Meteorological Observations	52	17	6
Foreign Scientific Memoirs	112	1	6
Working Population	100	0	0
School Statistics	50	0	0
Forms of Vessels	184	7	0
Chemical and Electrical Phenomena	40	0	0
Meteorological Observations at Plymouth	80	0	0
Magnetical Observations	185	13	9
	£1546	16	4

1841.

	£	s.	d.
Observations on Waves	30	0	0
Meteorology and Subterranean Temperature	8	8	0
Actinometers	10	0	0
Earthquake Shocks	17	7	0
Acrid Poisons	6	0	0
Veins and Absorbents	3	0	0
Mud in Rivers	5	0	0
Marine Zoology	15	12	8
Skeleton Maps	20	0	0
Mountain Barometers	6	18	6
Stars (Histoire Céleste)	185	0	0
Stars (Lacaille)	79	5	0
Stars (Nomenclature of)	17	19	6
Stars (Catalogue of)	40	0	0
Water on Iron	50	0	0
Meteorological Observations at Inverness	20	0	0
Meteorological Observations (reduction of)	25	0	0
Fossil Reptiles	50	0	0
Foreign Memoirs	62	0	6
Railway Sections	38	1	0
Forms of Vessels	193	12	0
Meteorological Observations at Plymouth	55	0	0
Magnetical Observations	61	18	8
Fishes of the Old Red Sandstone	100	0	0
Tides at Leith	50	0	0
Anemometer at Edinburgh	69	1	10
Tabulating Observations	9	6	3
Races of Men	5	0	0
Radiate Animals	2	0	0
	£1235	10	11

1842.

	£	s.	d.
Dynamometric Instruments	113	11	2
Anoplura Britanniæ	52	12	0
Tides at Bristol	59	8	0
Gases on Light	30	14	7
Chronometers	26	17	6
Marine Zoology	1	5	0
British Fossil Mammalia	100	0	0
Statistics of Education	20	0	0
Marine Steam-vessels' Engines	28	0	0
Stars (Histoire Céleste)	59	0	0
Stars (Brit. Assoc. Cat. of)	110	0	0
Railway Sections	161	10	0
British Belemnites	50	0	0
Fossil Reptiles (publication of Report)	210	0	0
Forms of Vessels	180	0	0
Galvanic Experiments on Rocks	5	8	6
Meteorological Experiments at Plymouth	68	0	0
Constant Indicator and Dynamometric Instruments	90	0	0
Force of Wind	10	0	0
Light on Growth of Seeds	8	0	0
Vital Statistics	50	0	0
Vegetative Power of Seeds	8	1	11
Questions on Human Race	7	9	0
	£1449	17	8

1843.

	£	s.	d.
Revision of the Nomenclature of Stars	2	0	0
Reduction of Stars, British Association Catalogue	25	0	0
Anomalous Tides, Firth of Forth	120	0	0
Hourly Meteorological Observations at Kingussie and Inverness	77	12	8
Meteorological Observations at Plymouth	55	0	0
Whewell's Meteorological Anemometer at Plymouth	10	0	0
Meteorological Observations, Osler's Anemometer at Plymouth	20	0	0
Reduction of Meteorological Observations	30	0	0
Meteorological Instruments and Gratuities	39	6	0
Construction of Anemometer at Inverness	56	12	2
Magnetic Co-operation	10	8	10
Meteorological Recorder for Kew Observatory	50	0	0
Action of Gases on Light	18	16	1
Establishment at Kew Observatory, Wages, Repairs, Furniture, and Sundries	133	4	7
Experiments by Captive Balloons	81	8	0
Oxidation of the Rails of Railways	20	0	0
Publication of Report on Fossil Reptiles	40	0	0
Coloured Drawings of Railway Sections	147	18	3
Registration of Earthquake Shocks	30	0	0
Report on Zoological Nomenclature	10	0	0
Uncovering Lower Red Sandstone near Manchester	4	4	6
Vegetative Power of Seeds	5	3	8
Marine Testacea (Habits of)	10	0	0
Marine Zoology	10	0	0
Marine Zoology	2	14	11
Preparation of Report on British Fossil Mammalia	100	0	0
Physiological Operations of Medicinal Agents	20	0	0
Vital Statistics	36	5	8

	£	s.	d.
Additional Experiments on the Forms of Vessels	70	0	0
Additional Experiments on the Forms of Vessels	100	0	0
Reduction of Experiments on the Forms of Vessels	100	0	0
Morin's Instrument and Constant Indicator	69	14	10
Experiments on the Strength of Materials	60	0	0
	£1565	10	2

1844.

	£	s.	d.
Meteorological Observations at Kingussie and Inverness	12	0	0
Completing Observations at Plymouth	35	0	0
Magnetic and Meteorological Co-operation	25	8	4
Publication of the British Association Catalogue of Stars	35	0	0
Observations on Tides on the East Coast of Scotland ...	100	0	0
Revision of the Nomenclature of Stars 1842	2	9	6
Maintaining the Establishment at Kew Observatory	117	17	3
Instruments for Kew Observatory	56	7	3
Influence of Light on Plants	10	0	0
Subterraneous Temperature in Ireland	5	0	0
Coloured Drawings of Railway Sections	15	17	6
Investigation of Fossil Fishes of the Lower Tertiary Strata	100	0	0
Registering the Shocks of Earthquakes 1842	23	11	10
Structure of Fossil Shells ...	20	0	0
Radiata and Mollusca of the Ægean and Red Seas 1842	100	0	0
Geographical Distributions of Marine Zoology.........1842	0	10	0
Marine Zoology of Devon and Cornwall	10	0	0
Marine Zoology of Corfu......	10	0	0
Experiments on the Vitality of Seeds	9	0	0
Experiments on the Vitality of Seeds 1842	8	7	3
Exotic Anoplura	15	0	0
Strength of Materials	100	0	0
Completing Experiments on the Forms of Ships	100	0	0
Inquiries into Asphyxia	10	0	0
Investigations on the Internal Constitution of Metals......	50	0	0
Constant Indicator and Morin's Instrument 1842	10	0	0
	£981	12	8

1845.

	£	s.	d.
Publication of the British Association Catalogue of Stars	351	14	6
Meteorological Observations at Inverness	30	18	11
Magnetic and Meteorological Co-operation	16	16	8
Meteorological Instruments at Edinburgh..................	18	11	9
Reduction of Anemometrical Observations at Plymouth	25	0	0
Electrical Experiments at Kew Observatory	43	17	8
Maintaining the Establishment at Kew Observatory	149	15	0
For Kreil's Barometrograph	25	0	0
Gases from Iron Furnaces...	50	0	0
The Actinograph	15	0	0
Microscopic Structure of Shells	20	0	0
Exotic Anoplura 1843	10	0	0
Vitality of Seeds 1843	2	0	7
Vitality of Seeds 1844	7	0	0
Marine Zoology of Cornwall .	10	0	0
Physiological Action of Medicines	20	0	0
Statistics of Sickness and Mortality in York...........	20	0	0
Earthquake Shocks 1843	15	14	8
	£831	9	9

1846.

	£	s.	d.
British Association Catalogue of Stars 1844	211	15	0
Fossil Fishes of the London Clay..............................	100	0	0
Computation of the Gaussian Constants for 1829	50	0	0
Maintaining the Establishment at Kew Observatory	146	16	7
Strength of Materials	60	0	0
Researches in Asphyxia	6	16	2
Examination of Fossil Shells	10	0	0
Vitality of Seeds 1844	2	15	10
Vitality of Seeds 1845	7	12	3
Marine Zoology of Cornwall	10	0	0
Marine Zoology of Britain ...	10	0	0
Exotic Anoplura 1844	25	0	0
Expenses attending Anemometers................................	11	7	6
Anemometers' Repairs..........	2	3	6
Atmospheric Waves	3	3	3
Captive Balloons 1844	8	19	8
Varieties of the Human Race 1844	7	6	3
Statistics of Sickness and Mortality in York	12	0	0
	£685	16	0

1847.

	£	s.	d.
Computation of the Gaussian Constants for 1829	50	0	0
Habits of Marine Animals	10	0	0
Physiological Action of Medicines	20	0	0
Marine Zoology of Cornwall	10	0	0
Atmospheric Waves	6	9	3
Vitality of Seeds	4	7	7
Maintaining the Establishment at Kew Observatory	107	8	6
	£208	5	4

1848.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	171	15	11
Atmospheric Waves	3	10	9
Vitality of Seeds	9	15	0
Completion of Catalogue of Stars	70	0	0
On Colouring Matters	5	0	0
On Growth of Plants	15	0	0
	£275	1	8

1849.

	£	s.	d.
Electrical Observations at Kew Observatory	50	0	0
Maintaining the Establishment at ditto	76	2	5
Vitality of Seeds	5	8	1
On Growth of Plants	5	0	0
Registration of Periodical Phenomena	10	0	0
Bill on Account of Anemometrical Observations	13	9	0
	£159	19	6

1850.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	255	18	0
Transit of Earthquake Waves	50	0	0
Periodical Phenomena	15	0	0
Meteorological Instruments, Azores	25	0	0
	£345	18	0

1851.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (includes part of grant in 1849)	309	2	2
Theory of Heat	20	1	1
Periodical Phenomena of Animals and Plants	5	0	0
Vitality of Seeds	5	6	4
Influence of Solar Radiation	30	0	0
Ethnological Inquiries	12	0	0
Researches on Annelida	10	0	0
	£391	9	7

1852.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (including balance of grant for 1850)	233	17	8
Experiments on the Conduction of Heat	5	2	9
Influence of Solar Radiations	20	0	0
Geological Map of Ireland	15	0	0
Researches on the British Annelida	10	0	0
Vitality of Seeds	10	6	2
Strength of Boiler Plates	10	0	0
	£304	6	7

1853.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	165	0	0
Experiments on the Influence of Solar Radiation	15	0	0
Researches on the British Annelida	10	0	0
Dredging on the East Coast of Scotland	10	0	0
Ethnological Queries	5	0	0
	£205	0	0

1854.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (including balance of former grant)	330	15	4
Investigations on Flax	11	0	0
Effects of Temperature on Wrought Iron	10	0	0
Registration of Periodical Phenomena	10	0	0
British Annelida	10	0	0
Vitality of Seeds	5	2	3
Conduction of Heat	4	2	0
	£380	19	7

1855.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	425	0	0
Earthquake Movements	10	0	0
Physical Aspect of the Moon	11	8	5
Vitality of Seeds	10	7	11
Map of the World	15	0	0
Ethnological Queries	5	0	0
Dredging near Belfast	4	0	0
	£480	16	4

1856.

	£	s.	d.
Maintaining the Establishment at Kew Observatory:— 1854......£ 75 0 0; 1855......£500 0 0	575	0	0

	£	s.	d.
Strickland's Ornithological Synonyms	100	0	0
Dredging and Dredging Forms	9	13	0
Chemical Action of Light	20	0	0
Strength of Iron Plates	10	0	0
Registration of Periodical Phenomena	10	0	0
Propagation of Salmon	10	0	0
	£734	13	9

1857.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	350	0	0
Earthquake Wave Experiments	40	0	0
Dredging near Belfast	10	0	0
Dredging on the West Coast of Scotland	10	0	0
Investigations into the Mollusca of California	10	0	0
Experiments on Flax	5	0	0
Natural History of Madagascar	20	0	0
Researches on British Annelida	25	0	0
Report on Natural Products imported into Liverpool	10	0	0
Artificial Propagation of Salmon	10	0	0
Temperature of Mines	7	8	0
Thermometers for Subterranean Observations	5	7	4
Life-boats	5	0	0
	£507	15	4

1858.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Earthquake Wave Experiments	25	0	0
Dredging on the West Coast of Scotland	10	0	0
Dredging near Dublin	5	0	0
Vitality of Seed	5	5	0
Dredging near Belfast	18	13	2
Report on the British Annelida	25	0	0
Experiments on the production of Heat by Motion in Fluids	20	0	0
Report on the Natural Products imported into Scotland	10	0	0
	£618	18	2

1859.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Dredging near Dublin	15	0	0
Osteology of Birds	50	0	0
Irish Tunicata	5	0	0
Manure Experiments	20	0	0
British Medusidæ	5	0	0
Dredging Committee	5	0	0
Steam-vessels' Performance	5	0	0
Marine Fauna of South and West of Ireland	10	0	0
Photographic Chemistry	10	0	0
Lanarkshire Fossils	20	0	1
Balloon Ascents	39	11	0
	£684	11	1

1860.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Dredging near Belfast	16	6	0
Dredging in Dublin Bay	15	0	0
Inquiry into the Performance of Steam-vessels	124	0	0
Explorations in the Yellow Sandstone of Dura Den	20	0	0
Chemico-mechanical Analysis of Rocks and Minerals	25	0	0
Researches on the Growth of Plants	10	0	0
Researches on the Solubility of Salts	30	0	0
Researches on the Constituents of Manures	25	0	0
Balance of Captive Balloon Accounts	1	13	6
	£766	19	6

1861.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Earthquake Experiments	25	0	0
Dredging North and East Coasts of Scotland	23	0	0
Dredging Committee:— 1860......£50 0 0; 1861......£22 0 0	72	0	0
Excavations at Dura Den	20	0	0
Solubility of Salts	20	0	0
Steam-vessel Performance	150	0	0
Fossils of Lesmahagow	15	0	0
Explorations at Uriconium	20	0	0
Chemical Alloys	20	0	0
Classified Index to the Transactions	100	0	0
Dredging in the Mersey and Dee	5	0	0
Dip Circle	30	0	0
Photoheliographic Observations	50	0	0
Prison Diet	20	0	0
Gauging of Water	10	0	0
Alpine Ascents	6	5	10
Constituents of Manures	25	0	0
	£1111	5	10

1862.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Patent Laws	21	6	0
Mollusca of N.-W. of America	10	0	0
Natural History by Mercantile Marine	5	0	0
Tidal Observations	25	0	0
Photoheliometer at Kew	40	0	0
Photographic Pictures of the Sun	150	0	0
Rocks of Donegal	25	0	0
Dredging Durham and Northumberland Coasts	25	0	0
Connection of Storms	20	0	0
Dredging North-east Coast of Scotland	6	9	6
Ravages of Teredo	3	11	0
Standards of Electrical Resistance	50	0	0
Railway Accidents	10	0	0
Balloon Committee	200	0	0
Dredging Dublin Bay	10	0	0
Dredging the Mersey	5	0	0
Prison Diet	20	0	0
Gauging of Water	12	10	0
Steamships' Performance	150	0	0
Thermo-electric Currents	5	0	0
	£1293	16	6

1863.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Balloon Committee deficiency	70	0	0
Balloon Ascents (other expenses)	25	0	0
Entozoa	25	0	0
Coal Fossils	20	0	0
Herrings	20	0	0
Granites of Donegal	5	0	0
Prison Diet	20	0	0
Vertical Atmospheric Movements	13	0	0
Dredging Shetland	50	0	0
Dredging North-east Coast of Scotland	25	0	0
Dredging Northumberland and Durham	17	3	10
Dredging Committee superintendence	10	0	0
Steamship Performance	100	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Volcanic Temperature	100	0	0
Bromide of Ammonium	8	0	0
Electrical Standards	100	0	0
Electrical Construction and Distribution	40	0	0
Luminous Meteors	17	0	0
Kew Additional Buildings for Photoheliograph	100	0	0
Thermo-electricity	15	0	0
Analysis of Rocks	8	0	0
Hydroida	10	0	0
	£1608	3	10

1864.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Coal Fossils	20	0	0
Vertical Atmospheric Movements	20	0	0
Dredging, Shetland	75	0	0
Dredging, Northumberland	25	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Standards of Electric Resistance	100	0	0
Analysis of Rocks	10	0	0
Hydroida	10	0	0
Askham's Gift	50	0	0
Nitrite of Amyle	10	0	0
Nomenclature Committee	5	0	0
Rain-gauges	19	15	8
Cast-iron Investigation	20	0	0
Tidal Observations in the Humber	50	0	0
Spectral Rays	45	0	0
Luminous Meteors	20	0	0
	£1289	15	8

1865.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Balloon Committee	100	0	0
Hydroida	13	0	0
Rain-gauges	30	0	0
Tidal Observations in the Humber	6	8	0
Hexylic Compounds	20	0	0
Amyl Compounds	20	0	0
Irish Flora	25	0	0
American Mollusca	3	9	0
Organic Acids	20	0	0
Lingula Flags Excavation	10	0	0
Eurypterus	50	0	0
Electrical Standards	100	0	0
Malta Caves Researches	30	0	0
Oyster Breeding	25	0	0
Gibraltar Caves Researches	150	0	0
Kent's Hole Excavations	100	0	0
Moon's Surface Observations	35	0	0
Marine Fauna	25	0	0
Dredging Aberdeenshire	25	0	0
Dredging Channel Islands	50	0	0
Zoological Nomenclature	5	0	0
Resistance of Floating Bodies in Water	100	0	0
Bath Waters Analysis	8	10	10
Luminous Meteors	40	0	0
	£1591	7	10

1866.

	£	s.	d.
Maintaining the Establishment at Kew Observatory..	600	0	0
Lunar Committee	64	13	4
Balloon Committee	50	0	0
Metrical Committee	50	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	16	0	0
Alum Bay Fossil Leaf-bed ...	15	0	0
Luminous Meteors	50	0	0
Lingula Flags Excavation ...	20	0	0
Chemical Constitution of Cast Iron	50	0	0
Amyl Compounds	25	0	0
Electrical Standards	100	0	0
Malta Caves Exploration	30	0	0
Kent's Hole Exploration	200	0	0
Marine Fauna, &c., Devon and Cornwall	25	0	0
Dredging Aberdeenshire Coast	25	0	0
Dredging Hebrides Coast ...	50	0	0
Dredging the Mersey	5	0	0
Resistance of Floating Bodies in Water	50	0	0
Polycyanides of Organic Radicals	29	0	0
Rigor Mortis	10	0	0
Irish Annelida	15	0	0
Catalogue of Crania	50	0	0
Didine Birds of Mascarene Islands	50	0	0
Typical Crania Researches ...	30	0	0
Palestine Exploration Fund...	100	0	0
	£1750	13	4

1867.

	£	s.	d.
Maintaining the Establishment at Kew Observatory..	600	0	0
Meteorological Instruments, Palestine	50	0	0
Lunar Committee	120	0	0
Metrical Committee	30	0	0
Kent's Hole Explorations ...	100	0	0
Palestine Explorations	50	0	0
Insect Fauna, Palestine	30	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	25	0	0
Alum Bay Fossil Leaf-bed ...	25	0	0
Luminous Meteors	50	0	0
Bournemouth, &c., Leaf-beds	30	0	0
Dredging Shetland	75	0	0
Steamship Reports Condensation	100	0	0
Electrical Standards	100	0	0
Ethyl and Methyl Series	25	0	0
Fossil Crustacea	25	0	0
Sound under Water	24	4	0
North Greenland Fauna	75	0	0
Do. Plant Beds	100	0	0
Iron and Steel Manufacture...	25	0	0
Patent Laws	30	0	0
	£1739	4	0

1868.

	£	s.	d.
Maintaining the Establishment at Kew Observatory..	600	0	0
Lunar Committee	120	0	0
Metrical Committee	50	0	0
Zoological Record	100	0	0
Kent's Hole Explorations ...	150	0	0
Steamship Performances	100	0	0
British Rainfall	50	0	0
Luminous Meteors	50	0	0
Organic Acids	60	0	0
Fossil Crustacea	25	0	0
Methyl Series	25	0	0
Mercury and Bile	25	0	0
Organic Remains in Limestone Rocks	25	0	0
Scottish Earthquakes	20	0	0
Fauna, Devon and Cornwall..	30	0	0
British Fossil Corals	50	0	0
Bagshot Leaf-beds	50	0	0
Greenland Explorations	100	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature ...	50	0	0
Spectroscopic Investigations of Animal Substances	5	0	0
Secondary Reptiles, &c.	30	0	0
British Marine Invertebrate Fauna	100	0	0
	£1940	0	0

1869.

	£	s.	d.
Maintaining the Establishment at Kew Observatory..	600	0	0
Lunar Committee	50	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Committee on Gases in Deep-well Water	25	0	0
British Rainfall	50	0	0
Thermal Conductivity of Iron, &c.	30	0	0
Kent's Hole Explorations	150	0	0
Steamship Performances	30	0	0
Chemical Constitution of Cast Iron	80	0	0
Iron and Steel Manufacture	100	0	0
Methyl Series	30	0	0
Organic Remains in Limestone Rocks	10	0	0
Earthquakes in Scotland	10	0	0
British Fossil Corals	50	0	0
Bagshot Leaf-beds	30	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature ...	30	0	0
Spectroscopic Investigations of Animal Substances	5	0	0
Organic Acids	12	0	0
Kiltorcan Fossils	20	0	0

	£	s.	d.
Chemical Constitution and Physiological Action Relations	15	0	0
Mountain Limestone Fossils	25	0	0
Utilisation of Sewage	10	0	0
Products of Digestion	10	0	0
	£1622	0	0

	£	s.	d.
Fossil Coral Sections, for Photographing	20	0	0
Bagshot Leaf-beds	20	0	0
Moab Explorations	100	0	0
Gaussian Constants	40	0	0
	£1472	2	6

1870.

Maintaining the Establishment at Kew Observatory	600	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Committee on Marine Fauna	20	0	0
Ears in Fishes	10	0	0
Chemical Nature of Cast Iron	80	0	0
Luminous Meteors	30	0	0
Heat in the Blood	15	0	0
British Rainfall	100	0	0
Thermal Conductivity of Iron, &c.	20	0	0
British Fossil Corals	50	0	0
Kent's Hole Explorations	150	0	0
Scottish Earthquakes	4	0	0
Bagshot Leaf-beds	15	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	50	0	0
Kiltorcan Quarries Fossils	20	0	0
Mountain Limestone Fossils	25	0	0
Utilisation of Sewage	50	0	0
Organic Chemical Compounds	30	0	0
Onny River Sediment	3	0	0
Mechanical Equivalent of Heat	50	0	0
	£1572	0	0

1871.

Maintaining the Establishment at Kew Observatory	600	0	0
Monthly Reports of Progress in Chemistry	100	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Thermal Equivalents of the Oxides of Chlorine	10	0	0
Tidal Observation	100	0	0
Fossil Flora	25	0	0
Luminous Meteors	30	0	0
British Fossil Corals	25	0	0
Heat in the Blood	7	2	6
British Rainfall	50	0	0
Kent's Hole Explorations	150	0	0
Fossil Crustacea	25	0	0
Methyl Compounds	25	0	0
Lunar Objects	20	0	0

1872.

Maintaining the Establishment at Kew Observatory	300	0	0
Metrical Committee	75	0	0
Zoological Record	100	0	0
Tidal Committee	200	0	0
Carboniferous Corals	25	0	0
Organic Chemical Compounds	25	0	0
Exploration of Moab	100	0	0
Terato-embryological Inquiries	10	0	0
Kent's Cavern Exploration	100	0	0
Luminous Meteors	20	0	0
Heat in the Blood	15	0	0
Fossil Crustacea	25	0	0
Fossil Elephants of Malta	25	0	0
Lunar Objects	20	0	0
Inverse Wave-lengths	20	0	0
British Rainfall	100	0	0
Poisonous Substances Antagonism	10	0	0
Essential Oils, Chemical Constitution, &c.	40	0	0
Mathematical Tables	50	0	0
Thermal Conductivity of Metals	25	0	0
	£1285	0	0

1873.

Zoological Record	100	0	0
Chemistry Record	200	0	0
Tidal Committee	400	0	0
Sewage Committee	100	0	0
Kent's Cavern Exploration	150	0	0
Carboniferous Corals	25	0	0
Fossil Elephants	25	0	0
Wave-lengths	150	0	0
British Rainfall	100	0	0
Essential Oils	30	0	0
Mathematical Tables	100	0	0
Gaussian Constants	10	0	0
Sub-Wealden Explorations	25	0	0
Underground Temperature	150	0	0
Settle Cave Exploration	50	0	0
Fossil Flora, Ireland	20	0	0
Timber Denudation and Rainfall	20	0	0
Luminous Meteors	30	0	0
	£1685	0	0

1874.

	£	s.	d.
Zoological Record	100	0	0
Chemistry Record	100	0	0
Mathematical Tables	100	0	0
Elliptic Functions	100	0	0
Lightning Conductors	10	0	0
Thermal Conductivity of Rocks	10	0	0
Anthropological Instructions	50	0	0
Kent's Cavern Exploration	150	0	0
Luminous Meteors	30	0	0
Intestinal Secretions	15	0	0
British Rainfall	100	0	0
Essential Oils	10	0	0
Sub-Wealden Explorations	25	0	0
Settle Cave Exploration	50	0	0
Mauritius Meteorology	100	0	0
Magnetisation of Iron	20	0	0
Marine Organisms	30	0	0
Fossils, North-West of Scotland	2	10	0
Physiological Action of Light	20	0	0
Trades Unions	25	0	0
Mountain Limestone Corals	25	0	0
Erratic Blocks	10	0	0
Dredging, Durham and Yorkshire Coasts	28	5	0
High Temperature of Bodies	30	0	0
Siemens's Pyrometer	3	6	0
Labyrinthodonts of Coal-measures	7	15	0
	£1151	16	0

1875.

	£	s.	d.
Elliptic Functions	100	0	0
Magnetisation of Iron	20	0	0
British Rainfall	120	0	0
Luminous Meteors	30	0	0
Chemistry Record	100	0	0
Specific Volume of Liquids	25	0	0
Estimation of Potash and Phosphoric Acid	10	0	0
Isometric Cresols	20	0	0
Sub-Wealden Explorations	100	0	0
Kent's Cavern Exploration	100	0	0
Settle Cave Exploration	50	0	0
Earthquakes in Scotland	15	0	0
Underground Waters	10	0	0
Development of Myxinoid Fishes	20	0	0
Zoological Record	100	0	0
Instructions for Travellers	20	0	0
Intestinal Secretions	20	0	0
Palestine Exploration	100	0	0
	£960	0	0

1876.

	£	s.	d.
Printing Mathematical Tables	159	4	2
British Rainfall	100	0	0
Ohm's Law	9	15	0
Tide Calculating Machine	200	0	0
Specific Volume of Liquids	25	0	0
Isomeric Cresols	10	0	0
Action of Ethyl Bromobutyrate on Ethyl Sodaceto-acetate	5	0	0
Estimation of Potash and Phosphoric Acid	13	0	0
Exploration of Victoria Cave	100	0	0
Geological Record	100	0	0
Kent's Cavern Exploration	100	0	0
Thermal Conductivities of Rocks	10	0	0
Underground Waters	10	0	0
Earthquakes in Scotland	1	10	0
Zoological Record	100	0	0
Close Time	5	0	0
Physiological Action of Sound	25	0	0
Naples Zoological Station	75	0	0
Intestinal Secretions	15	0	0
Physical Characters of Inhabitants of British Isles	13	15	0
Measuring Speed of Ships	10	0	0
Effect of Propeller on turning of Steam-vessels	5	0	0
	£1092	4	2

1877.

	£	s.	d.
Liquid Carbonic Acid in Minerals	20	0	0
Elliptic Functions	250	0	0
Thermal Conductivity of Rocks	9	11	7
Zoological Record	100	0	0
Kent's Cavern	100	0	0
Zoological Station at Naples	75	0	0
Luminous Meteors	30	0	0
Elasticity of Wires	100	0	0
Dipterocarpeæ, Report on	20	0	0
Mechanical Equivalent of Heat	35	0	0
Double Compounds of Cobalt and Nickel	8	0	0
Underground Temperature	50	0	0
Settle Cave Exploration	100	0	0
Underground Waters in New Red Sandstone	10	0	0
Action of Ethyl Bromobutyrate on Ethyl Sodaceto-acetate	10	0	0
British Earthworks	25	0	0
Atmospheric Electricity in India	15	0	0
Development of Light from Coal-gas	20	0	0
Estimation of Potash and Phosphoric Acid	1	18	0
Geological Record	100	0	0
Anthropometric Committee	34	0	0
Physiological Action of Phosphoric Acid, &c.	15	0	0
	£1128	9	7

1878.

	£	s.	d.
Exploration of Settle Caves	100	0	0
Geological Record	100	0	0
Investigation of Pulse Phenomena by means of Siphon Recorder	10	0	0
Zoological Station at Naples	75	0	0
Investigation of Underground Waters	15	0	0
Transmission of Electrical Impulses through Nerve Structure	30	0	0
Calculation of Factor Table for 4th Million	100	0	0
Anthropometric Committee	66	0	0
Composition and Structure of less-known Alkaloids	25	0	0
Exploration of Kent's Cavern	50	0	0
Zoological Record	100	0	0
Fermanagh Caves Exploration	15	0	0
Thermal Conductivity of Rocks	4	16	6
Luminous Meteors	10	0	0
Ancient Earthworks	25	0	0
	£725	16	6

1879.

	£	s.	d.
Table at the Zoological Station, Naples	75	0	0
Miocene Flora of the Basalt of the North of Ireland	20	0	0
Illustrations for a Monograph on the Mammoth	17	0	0
Record of Zoological Literature	100	0	0
Composition and Structure of less-known Alkaloids	25	0	0
Exploration of Caves in Borneo	50	0	0
Kent's Cavern Exploration	100	0	0
Record of the Progress of Geology	100	0	0
Fermanagh Caves Exploration	5	0	0
Electrolysis of Metallic Solutions and Solutions of Compound Salts	25	0	0
Anthropometric Committee	50	0	0
Natural History of Socotra	100	0	0
Calculation of Factor Tables for 5th and 6th Millions	150	0	0
Underground Waters	10	0	0
Steering of Screw Steamers	10	0	0
Improvements in Astronomical Clocks	30	0	0
Marine Zoology of South Devon	20	0	0
Determination of Mechanical Equivalent of Heat	12	15	6
Specific Inductive Capacity of Sprengel Vacuum	40	0	0
Tables of Sun-heat Coefficients	30	0	0
Datum Level of the Ordnance Survey	10	0	0
Tables of Fundamental Invariants of Algebraic Forms	36	14	9
Atmospheric Electricity Observations in Madeira	15	0	0
Instrument for Detecting Fire-damp in Mines	22	0	0
Instruments for Measuring the Speed of Ships	17	1	8
Tidal Observations in the English Channel	10	0	0
	£1080	11	11

1880.

	£	s.	d.
New Form of High Insulation Key	10	0	0
Underground Temperature	10	0	0
Determination of the Mechanical Equivalent of Heat	8	5	0
Elasticity of Wires	50	0	0
Luminous Meteors	30	0	0
Lunar Disturbance of Gravity	30	0	0
Fundamental Invariants	8	5	0
Laws of Water Friction	20	0	0
Specific Inductive Capacity of Sprengel Vacuum	20	0	0
Completion of Tables of Sun-heat Coefficients	50	0	0
Instrument for Detection of Fire-damp in Mines	10	0	0
Inductive Capacity of Crystals and Paraffines	4	17	7
Report on Carboniferous Polyzoa	10	0	0
Caves of South Ireland	10	0	0
Viviparous Nature of Ichthyosaurus	10	0	0
Kent's Cavern Exploration	50	0	0
Geological Record	100	0	0
Miocene Flora of the Basalt of North Ireland	15	0	0
Underground Waters of Permian Formations	5	0	0
Record of Zoological Literature	100	0	0
Table at Zoological Station at Naples	75	0	0
Investigation of the Geology and Zoology of Mexico	50	0	0
Anthropometry	50	0	0
Patent Laws	5	0	0
	£731	7	7

1881.

	£	s.	d.
Lunar Disturbance of Gravity	30	0	0
Underground Temperature ...	20	0	0
Electrical Standards............	25	0	0
High Insulation Key............	5	0	0
Tidal Observations	10	0	0
Specific Refractions	7	3	1
Fossil Polyzoa	10	0	0
Underground Waters	10	0	0
Earthquakes in Japan	25	0	0
Tertiary Flora	20	0	0
Scottish Zoological Station ...	50	0	0
Naples Zoological Station ...	75	0	0
Natural History of Socotra ...	50	0	0
Anthropological Notes and Queries	9	0	0
Zoological Record..............	100	0	0
Weights and Heights of Human Beings	30	0	0
	£476	3	1

1882.

	£	s.	d.
Exploration of Central Africa	100	0	0
Fundamental Invariants of Algebraical Forms	76	1	11
Standards for Electrical Measurements	100	0	0
Calibration of Mercurial Thermometers	20	0	0
Wave-length Tables of Spectra of Elements..............	50	0	0
Photographing Ultra-violet Spark Spectra	25	0	0
Geological Record..............	100	0	0
Earthquake Phenomena of Japan	25	0	0
Conversion of Sedimentary Materials into Metamorphic Rocks	10	0	0
Fossil Plants of Halifax	15	0	0
Geological Map of Europe ...	25	0	0
Circulation of Underground Waters.........................	15	0	0
Tertiary Flora of North of Ireland	20	0	0
British Polyzoa	10	0	0
Exploration of Caves of South of Ireland	10	0	0
Exploration of Raygill Fissure	20	0	0
Naples Zoological Station ...	80	0	0
Albuminoid Substances of Serum	10	0	0
Elimination of Nitrogen by Bodily Exercise...............	50	0	0
Migration of Birds	15	0	0
Natural History of Socotra...	100	0	0
Natural History of Timor-laut	100	0	0
Record of Zoological Literature	100	0	0
Anthropometric Committee...	50	0	0
	£1126	1	11

1883.

	£	s.	d.
Meteorological Observations on Ben Nevis	50	0	0
Isomeric Naphthalene Derivatives...........................	15	0	0
Earthquake Phenomena of Japan	50	0	0
Fossil Plants of Halifax......	20	0	0
British Fossil Polyzoa	10	0	0
Fossil Phyllopoda of Palæozoic Rocks	25	0	0
Erosion of Sea-coast of England and Wales	10	0	0
Circulation of Underground Waters.........................	15	0	0
Geological Record..............	50	0	0
Exploration of Caves in South of Ireland	10	0	0
Zoological Literature Record	100	0	0
Migration of Birds	20	0	0
Zoological Station at Naples	80	0	0
Scottish Zoological Station...	25	0	0
Elimination of Nitrogen by Bodily Exercise..............	38	3	3
Exploration of Mount Kilima-njaro..................... .	500	0	0
Investigation of Loughton Camp	10	0	0
Natural History of Timor-laut	50	0	0
Screw Gauges......................	5	0	0
	£1083	3	3

1884.

	£	s.	d.
Meteorological Observations on Ben Nevis	50	0	0
Collecting and Investigating Meteoric Dust.................	20	0	0
Meteorological Observatory at Chepstow.......................	25	0	0
Tidal Observations..............	10	0	0
Ultra Violet Spark Spectra ...	8	4	0
Earthquake Phenomena of Japan	75	0	0
Fossil Plants of Halifax	15	0	0
Fossil Polyzoa....................	10	0	0
Erratic Blocks of England ...	10	0	0
Fossil Phyllopoda of Palæozoic Rocks	15	0	0
Circulation of Underground Waters.........................	5	0	0
International Geological Map	20	0	0
Bibliography of Groups of Invertebrata	50	0	0
Natural History of Timor-laut	50	0	0
Naples Zoological Station ...	80	0	0
Exploration of Mount Kilima-njaro, East Africa	500	0	0
Migration of Birds..............	20	0	0
Coagulation of Blood...........	100	0	0
Zoological Literature Record	100	0	0
Anthropometric Committee...	10	0	0
	£1173	4	0

1885.

	£	s.	d.
Synoptic Chart of Indian Ocean	50	0	0
Reduction of Tidal Observations	10	0	0
Calculating Tables in Theory of Numbers	100	0	0
Meteorological Observations on Ben Nevis	50	0	0
Meteoric Dust	70	0	0
Vapour Pressures, &c., of Salt Solutions	25	0	0
Physical Constants of Solutions	20	0	0
Volcanic Phenomena of Vesuvius	25	0	0
Raygill Fissure	15	0	0
Earthquake Phenomena of Japan	70	0	0
Fossil Phyllopoda of Palæozoic Rocks	25	0	0
Fossil Plants of British Tertiary and Secondary Beds	50	0	0
Geological Record	50	0	0
Circulation of Underground Waters	10	0	0
Naples Zoological Station	100	0	0
Zoological Literature Record	100	0	0
Migration of Birds	30	0	0
Exploration of Mount Kilimanjaro	25	0	0
Recent Polyzoa	10	0	0
Granton Biological Station	100	0	0
Biological Stations on Coasts of United Kingdom	150	0	0
Exploration of New Guinea	200	0	0
Exploration of Mount Roraima	100	0	0
	£1385	0	0

1886.

	£	s.	d.
Electrical Standards	40	0	0
Solar Radiation	9	10	6
Tidal Observations	50	0	0
Magnetic Observations	10	10	0
Observations on Ben Nevis	100	0	0
Physical and Chemical Bearings of Electrolysis	20	0	0
Chemical Nomenclature	5	0	0
Fossil Plants of British Tertiary and Secondary Beds	20	0	0
Caves in North Wales	25	0	0
Volcanic Phenomena of Vesuvius	30	0	0
Geological Record	100	0	0
Palæozoic Phyllopoda	15	0	0
Zoological Literature Record	100	0	0
Granton Biological Station	75	0	0
Naples Zoological Station	50	0	0
Researches in Food-Fishes and Invertebrata at St. Andrews	75	0	0
Migration of Birds	30	0	0
Secretion of Urine	10	0	0
Exploration of New Guinea	150	0	0
Regulation of Wages under Sliding Scales	10	0	0
Prehistoric Race in Greek Islands	20	0	0
North-Western Tribes of Canada	50	0	0
	£995	0	6

1887.

	£	s.	d.
Solar Radiation	18	10	0
Electrolysis	30	0	0
Ben Nevis Observatory	75	0	0
Standards of Light (1886 grant)	20	0	0
Standards of Light (1887 grant)	10	0	0
Harmonic Analysis of Tidal Observations	15	0	0
Magnetic Observations	26	2	0
Electrical Standards	50	0	0
Silent Discharge of Electricity	20	0	0
Absorption Spectra	40	0	
Nature of Solution	20	0	0
Influence of Silicon on Steel	30	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Volcanic Phenomena of Japan (1886 grant)	50	0	0
Volcanic Phenomena of Japan (1887 grant)	50	0	0
Cae Gwyn Cave, N. Wales	20	0	0
Erratic Blocks	10	0	0
Fossil Phyllopoda	20	0	0
Coal Plants of Halifax	25	0	0
Microscopic Structure of the Rocks of Anglesey	10	0	0
Exploration of the Eocene Beds of the Isle of Wight	20	0	0
Underground Waters	5	0	0
'Manure' Gravels of Wexford	10	0	0
Provincial Museums Reports	5	0	0
Lymphatic System	25	0	0
Naples Biological Station	100	0	0
Plymouth Biological Station	50	0	0
Granton Biological Station	75	0	0
Zoological Record	100	0	0
Flora of China	75	0	0
Flora and Fauna of the Cameroons	75	0	0
Migration of Birds	30	0	0
Bathy-hypsographical Map of British Isles	7	6	0
Regulation of Wages	10	0	0
Prehistoric Race of Greek Islands	20	0	0
Racial Photographs, Egyptian	20	0	0
	£1186	18	0

1888.

	£	s.	d.
Ben Nevis Observatory.........	150	0	0
Electrical Standards............	2	6	4
Magnetic Observations.........	15	0	0
Standards of Light	79	2	3
Electrolysis	30	0	0
Uniform Nomenclature in Mechanics	10	0	0
Silent Discharge of Electricity	9	11	10
Properties of Solutions	25	0	0
Influence of Silicon on Steel	20	0	0
Methods of Teaching Chemistry	10	0	0
Isomeric Naphthalene Derivatives............................	25	0	0
Action of Light on Hydracids	20	0	0
Sea Beach near Bridlington...	20	0	0
Geological Record	50	0	0
Manure Gravels of Wexford...	10	0	0
Erosion of Sea Coasts	10	0	0
Underground Waters	5	0	0
Palæontographical Society ...	50	0	0
Pliocene Fauna of St. Erth...	50	0	0
Carboniferous Flora of Lancashire and West Yorkshire	25	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Zoology and Botany of West Indies	100	0	0
Flora of Bahamas	100	0	0
Development of Fishes—St. Andrews	50	0	0
Marine Laboratory, Plymouth	100	0	0
Migration of Birds	30	0	0
Flora of China	75	0	0
Naples Zoological Station ...	100	0	0
Lymphatic System	25	0	0
Biological Station at Granton	50	0	0
Peradeniya Botanical Station	50	0	0
Development of Teleostei ...	15	0	0
Depth of Frozen Soil in Polar Regions	5	0	0
Precious Metals in Circulation	20	0	0
Value of Monetary Standard	10	0	0
Effect of Occupations on Physical Development...........	25	0	0
North-Western Tribes of Canada	100	0	0
Prehistoric Race in Greek Islands..........................	20	0	0
	£1511	0	5

1889.

	£	s.	d.
Ben Nevis Observatory.........	50	0	0
Electrical Standards...........	75	0	0
Electrolysis.......................	20	0	0
Surface Water Temperature...	30	0	0
Silent Discharge of Electricity on Oxygen	6	4	8
Methods of teaching Chemistry	10	0	0
Action of Light on Hydracids	10	0	0
Geological Record...............	80	0	0
Volcanic Phenomena of Japan	25	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Palæozoic Phyllopoda	20	0	0
Higher Eocene Beds of Isle of Wight	15	0	0
West Indian Explorations ...	100	0	0
Flora of China	25	0	0
Naples Zoological Station ...	100	0	0
Physiology of Lymphatic System	25	0	0
Experiments with a Tow-net	5	16	3
Natural History of Friendly Islands..........................	100	0	0
Geology and Geography of Atlas Range	100	0	0
Action of Waves and Currents in Estuaries	100	0	0
North-Western Tribes of Canada	150	0	0
Nomad Tribes of Asia Minor	30	0	0
Corresponding Societies	20	0	0
Marine Biological Association	200	0	0
'Baths Committee,' Bath.. ...	100	0	0
	£1417	0	11

1890.

	£	s.	d.
Electrical Standards...........	12	17	0
Electrolysis	5	0	0
Electro-optics.....................	50	0	0
Mathematical Tables	25	0	0
Volcanic and Seismological Phenomena of Japan	75	0	0
Pellian Equation Tables	15	0	0
Properties of Solutions	10	0	0
International Standard for the Analysis of Iron and Steel	10	0	0
Influence of the Silent Discharge of Electricity on Oxygen	5	0	0
Methods of teaching Chemistry	10	0	0
Recording Results of Water Analysis	4	1	0
Oxidation of Hydracids in Sunlight	15	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Palæozoic Phyllopoda	10	0	0
Circulation of Underground Waters..........................	5	0	0
Excavations at Oldbury Hill	15	0	0
Cretaceous Polyzoa	10	0	0
Geological Photographs	7	14	11
Lias Beds of Northampton ...	25	0	0
Botanical Station at Peradeniya	25	0	0

	£	s.	d.
Experiments with a Tow-net	4	3	9
Naples Zoological Station ...	100	0	0
Zoology and Botany of the West India Islands	100	0	0
Marine Biological Association	30	0	0
Action of Waves and Currents in Estuaries	150	0	0
Graphic Methods in Mechanical Science	11	0	0
Anthropometric Calculations	5	0	0
Nomad Tribes of Asia Minor	25	0	0
Corresponding Societies	20	0	0
	£799	16	8

1891.

	£	s.	d.
Ben Nevis Observatory.........	50	0	0
Electrical Standards...........	100	0	0
Electrolysis.......................	5	0	0
Seismological Phenomena of Japan	10	0	0
Temperatures of Lakes.........	20	0	0
Photographs of Meteorological Phenomena....................	5	0	0
Discharge of Electricity from Points	10	0	0
Ultra Violet Rays of Solar Spectrum	50	0	0
International Standard for Analysis of Iron and Steel...	10	0	0
Isomeric Naphthalene Derivatives............................	25	0	0
Formation of Haloids	25	0	0
Action of Light on Dyes	17	10	0
Geological Record..............	100	0	0
Volcanic Phenomena of Vesuvius	10	0	0
Fossil Phyllopoda..............	10	0	0
Photographs of Geological Interest	9	5	0
Lias of Northamptonshire ...	25	0	0
Registration of Type-Specimens of British Fossils......	5	5	0
Investigation of Elbolton Cave	25	0	0
Botanical Station at Peradeniya	50	0	0
Experiments with a Tow-net	40	0	0
Marine Biological Association	12	10	0
Disappearance of Native Plants	5	0	0
Action of Waves and Currents in Estuaries	125	0	0
Anthropometric Calculations	10	0	0
New Edition of 'Anthropological Notes and Queries'	50	0	0
North - Western Tribes of Canada	200	0	0
Corresponding Societies	25	0	0
	£1,029	10	0

1892.

	£	s.	d.
Observations on Ben Nevis ...	50	0	0
Photographs of Meteorological Phenomena....................	15	0	0
Pellian Equation Tables	10	0	0
Discharge of Electricity from Points	50	0	0
Seismological Phenomena of Japan	10	0	0
Formation of Haloids	12	0	0
Properties of Solutions	10	0	0
Action of Light on Dyed Colours	10	0	0
Erratic Blocks	15	0	0
Photographs of Geological Interest	20	0	0
Underground Waters	10	0	0
Investigation of Elbolton Cave............................	25	0	0
Excavations at Oldbury Hill	10	0	0
Cretaceous Polyzoa	10	0	0
Naples Zoological Station ...	100	0	0
Marine Biological Association	17	10	0
Deep-sea Tow-net	40	0	0
Fauna of Sandwich Islands...	100	0	0
Zoology and Botany of West India Islands	100	0	0
Climatology and Hydrography of Tropical Africa	50	0	0
Anthropometric Laboratory...	5	0	0
Anthropological Notes and Queries	20	0	0
Prehistoric Remains in Mashonaland	50	0	0
North - Western Tribes of Canada	100	0	0
Corresponding Societies	25	0	0
	£864	10	0

1893.

	£	s.	d.
Electrical Standards............	25	0	0
Observations on Ben Nevis ...	150	0	0
Mathematical Tables	15	0	0
Intensity of Solar Radiation	2	8	6
Magnetic Work at the Falmouth Observatory	25	0	0
Isomeric Naphthalene Derivatives	20	0	0
Erratic Blocks	10	0	0
Fossil Phyllopoda..............	5	0	0
Underground Waters	5	0	0
Shell-bearing Deposits at Clava, Chapelhall, &c.	20	0	0
Eurypterids of the Pentland Hills............................	10	0	0
Naples Zoological Station ...	100	0	0
Marine Biological Association	30	0	0
Fauna of Sandwich Islands	100	0	0
Zoology and Botany of West India Islands	50	0	0

	£	s.	d.
Exploration of Irish Sea	30	0	0
Physiological Action of Oxygen in Asphyxia	20	0	0
Index of Genera and Species of Animals	20	0	0
Exploration of Karakoram Mountains	50	0	0
Scottish Place-names	7	0	0
Climatology and Hydrography of Tropical Africa	50	0	0
Economic Training	3	7	0
Anthropometric Laboratory	5	0	0
Exploration in Abyssinia	25	0	0
North-Western Tribes of Canada	100	0	0
Corresponding Societies	30	0	0
	£907	15	6

1894.

	£	s.	d.
Electrical Standards	25	0	0
Photographs of Meteorological Phenomena	10	0	0
Tables of Mathematical Functions	15	0	0
Intensity of Solar Radiation	5	5	6
Wave-length Tables	10	0	0
Action of Light upon Dyed Colours	5	0	0
Erratic Blocks	15	0	0
Fossil Phyllopoda	5	0	0
Shell-bearing Deposits at Clava, &c.	20	0	0
Eurypterids of the Pentland Hills	5	0	0
New Sections of Stonesfield Slate	14	0	0
Observations on Earth-tremors	50	0	0
Exploration of Calf-Hole Cave	5	0	0
Naples Zoological Station	100	0	0
Marine Biological Association	5	0	0
Zoology of the Sandwich Islands	100	0	0
Zoology of the Irish Sea	40	0	0
Structure and Function of the Mammalian Heart	10	0	0
Exploration in Abyssinia	30	0	0
Economic Training	9	10	0
Anthropometric Laboratory Statistics	5	0	0
Ethnographical Survey	10	0	0
The Lake Village at Glastonbury	40	0	0
Anthropometrical Measurements in Schools	5	0	0
Mental and Physical Condition of Children	20	0	0
Corresponding Societies	25	0	0
	£583	15	6

1895.

	£	s.	d.
Electrical Standards	25	0	0
Photographs of Meteorological Phenomena	10	0	0
Earth Tremors	75	0	0
Abstracts of Physical Papers	100	0	0
Reduction of Magnetic Observations made at Falmouth Observatory	50	0	0
Comparison of Magnetic Standards	25	0	0
Meteorological Observations on Ben Nevis	50	0	0
Wave-length Tables of the Spectra of the Elements	10	0	0
Action of Light upon Dyed Colours	4	6	1
Formation of Haloids from Pure Materials	20	0	0
Isomeric Naphthalene Derivatives	30	0	0
Electrolytic Quantitative Analysis	30	0	0
Erratic Blocks	10	0	0
Palæozoic Phyllopoda	5	0	0
Photographs of Geological Interest	10	0	0
Shell-bearing Deposits at Clava, &c.	10	0	0
Eurypterids of the Pentland Hills	3	0	0
New Sections of Stonesfield Slate	50	0	0
Exploration of Calf Hole Cave	10	0	0
Nature and Probable Age of High-level Flint-drifts	10	0	0
Table at the Zoological Station at Naples	100	0	0
Table at the Biological Laboratory, Plymouth	15	0	0
Zoology, Botany, and Geology of the Irish Sea	35	9	4
Zoology and Botany of the West India Islands	50	0	0
Index of Genera and Species of Animals	50	0	0
Climatology of Tropical Africa	5	0	0
Exploration of Hadramut	50	0	0
Calibration and Comparison of Measuring Instruments	25	0	0
Anthropometric Measurements in Schools	5	0	0
Lake Village at Glastonbury	30	0	0
Exploration of a Kitchen-midden at Hastings	10	0	0
Ethnographical Survey	10	0	0
Physiological Applications of the Phonograph	25	0	0
Corresponding Societies	30	0	0
	£977	15	5

1896.

	£	s.	d.
Photographs of Meteorological Phenomena	15	0	0
Seismological Observations	80	0	0
Abstracts of Physical Papers	100	0	0
Calculation of certain Integrals	10	0	0
Uniformity of Size of Pages of Transactions, &c.	5	0	0
Wave-length Tables of the Spectra of the Elements	10	0	0
Action of Light upon Dyed Colours	2	6	1
Electrolytic Quantitative Analysis	10	0	0
The Carbohydrates of Barley Straw	50	0	0
Reprinting Discussion on the Relation of Agriculture to Science	5	0	0
Erratic Blocks	10	0	0
Palæozoic Phyllopoda	5	0	0
Shell-bearing Deposits at Clava, &c.	10	0	0
Eurypterids of the Pentland Hills	2	0	0
Investigation of a Coral Reef by Boring and Sounding	10	0	0
Examination of Locality where the Cetiosaurus in the Oxford Museum was found	25	0	0
Palæolithic Deposits at Hoxne	25	0	0
Fauna of Singapore Caves	40	0	0
Age and Relation of Rocks near Moreseat, Aberdeen	10	0	0
Table at the Zoological Station at Naples	100	0	0
Table at the Biological Laboratory, Plymouth	15	0	0
Zoology, Botany, and Geology of the Irish Sea	50	0	0
Zoology of the Sandwich Islands	100	0	0
African Lake Fauna	100	0	0
Oysters under Normal and Abnormal Environment	40	0	0
Climatology of Tropical Africa	10	0	0
Calibration and Comparison of Measuring Instruments	20	0	0
Small Screw Gauge	10	0	0
North-Western Tribes of Canada	100	0	0
Lake Village at Glastonbury	30	0	0
Ethnographical Survey	40	0	0
Mental and Physical Condition of Children	10	0	0
Physiological Applications of the Phonograph	25	0	0
Corresponding Societies Committee	30	0	0
	£1,104	6	1

1897.

	£	s.	d.
Mathematical Tables	25	0	0
Seismological Observations	100	0	0
Abstracts of Physical Papers	100	0	0
Calculation of certain Integrals	10	0	0
Electrolysis and Electro-chemistry	50	0	0
Electrolytic Quantitative Analysis	10	0	0
Isomeric Naphthalene Derivatives	50	0	0
Erratic Blocks	10	0	0
Photographs of Geological Interest	15	0	0
Remains of the Irish Elk in the Isle of Man	15	0	0
Table at the Zoological Station, Naples	100	0	0
Table at the Biological Laboratory, Plymouth	9	10	8
Zoological Bibliography and Publication	5	0	0
Index Generum et Specierum Animalium	100	0	0
Zoology and Botany of the West India Islands	40	0	0
The Details of Observations on the Migration of Birds	40	0	0
Climatology of Tropical Africa	20	0	0
Ethnographical Survey	40	0	0
Mental and Physical Condition of Children	10	0	0
Silchester Excavation	20	0	0
Investigation of Changes associated with the Functional Activity of Nerve Cells and their Peripheral Extensions	180	0	0
Oysters and Typhoid	30	0	0
Physiological Applications of the Phonograph	15	0	0
Physiological Effects of Peptone and its Precursors	20	0	0
Fertilisation in Phæophyceæ	20	0	0
Corresponding Societies Committee	25	0	0
	£1,059	10	8

1898.

	£	s.	d.
Electrical Standards	75	0	0
Seismological Observations	75	0	0
Abstracts of Physical Papers	100	0	0
Calculation of certain Integrals	10	0	0
Electrolysis and Electro-chemistry	35	0	0
Meteorological Observatory at Montreal	50	0	0

	£	s.	d.
Wave-length Tables of the Spectra of the Elements ...	20	0	0
Action of Light upon Dyed Colours ...	8	0	0
Erratic Blocks ...	5	0	0
Investigation of a Coral Reef	40	0	0
Photographs of Geological Interest ...	10	0	0
Life-zones in British Carboniferous Rocks ...	15	0	0
Pleistocene Fauna and Flora in Canada ...	20	0	0
Table at the Zoological Station, Naples ...	100	0	0
Table at the Biological Laboratory, Plymouth ...	14	0	0
Index Generum et Specierum Animalium ...	100	0	0
Healthy and Unhealthy Oysters ...	30	0	0
Climatology of Tropical Africa	10	0	0
State Monopolies in other Countries ...	15	0	0
Small Screw Gauge ...	20	0	0
North-Western Tribes of Canada ...	75	0	0
Lake Village at Glastonbury	37	10	0
Silchester Excavation ...	7	10	0
Ethnological Survey of Canada	75	0	0
Anthropology and Natural History of Torres Straits ...	125	0	0
Investigation of Changes associated with the Functional Activity of Nerve Cells and their Peripheral Extensions	100	0	0
Fertilisation in Phæophyceæ	15	0	0
Corresponding Societies Committee ...	25	0	0
	£1,212	0	0

1899.

	£	s.	d.
Electrical Standards ...	225	0	0
Seismological Observations ...	65	14	8
Science Abstracts ...	100	0	0
Heat of Combination of Metals in Alloys ...	20	0	0
Radiation in a Magnetic Field	50	0	0
Calculation of certain Integrals ...	10	0	0
Action of Light upon Dyed Colours ...	4	19	6
Relation between Absorption Spectra and Constitution of Organic Substances ...	50	0	0
Erratic Blocks ...	15	0	0
Photographs of Geological Interest ...	10	0	0
Remains of Irish Elk in the Isle of Man ...	15	0	0
Pleistocene Flora and Fauna in Canada ...	30	0	0
Records of Disappearing Drift Section at Moel Tryfaen ...	5	0	0
Ty Newydd Caves ...	40	0	0
Ossiferous Caves at Uphill ...	30	0	0
Table at the Zoological Station, Naples ...	100	0	0
Table at the Biological Laboratory, Plymouth ...	20	0	0
Index Generum et Specierum Animalium ...	100	0	0
Migration of Birds ...	15	0	0
Apparatus for Keeping Aquatic Organisms under Definite Physical Conditions ...	15	0	0
Plankton and Physical Conditions of the English Channel during 1899 ...	100	0	0
Exploration of Sokotra ...	35	0	0
Lake Village at Glastonbury	50	0	0
Silchester Excavation ...	10	0	0
Ethnological Survey of Canada	35	0	0
New Edition of 'Anthropological Notes and Queries' ...	40	0	0
Age of Stone Circles ...	20	0	0
Physiological Effects of Peptone ...	30	0	0
Electrical Changes accompanying Discharge of Respiratory Centres ...	20	0	0
Influence of Drugs upon the Vascular Nervous System ...	10	0	0
Histological Changes in Nerve Cells ...	20	0	0
Micro-chemistry of Cells ...	40	0	0
Histology of Suprarenal Capsules ...	20	0	0
Comparative Histology of Cerebral Cortex ...	10	0	0
Fertilisation in Phyæophyceæ	20	0	0
Assimilation in Plants ...	20	0	0
Zoological and Botanical Publication ...	5	0	0
Corresponding Societies Committee ...	25	0	0
	£1,430	14	2

1900.

	£	s.	d.
Electrical Standards ...	25	0	0
Seismological Observations ...	60	0	0
Radiation in a Magnetic Field	25	0	0
Meteorological Observatory at Montreal ...	20	0	0
Tables of Mathematical Functions ...	75	0	0
Relation between Absorption Spectra and Constitution of Organic Bodies ...	30	0	0
Wave-length Tables ...	5	0	0
Electrolytic Quantitative Analysis ...	5	0	0

	£	s.	d.
Isomorphous Sulphonic Derivatives of Benzene	20	0	0
The Nature of Alloys	30	0	0
Photographs of Geological Interest	10	0	0
Remains of Elk in the Isle of Man	5	0	0
Pleistocene Fauna and Flora in Canada	10	0	0
Movements of Underground Waters of Craven	40	0	0
Table at the Zoological Station, Naples	100	0	0
Table at the Biological Laboratory, Plymouth	20	0	0
Index Generum et Specierum Animalium	50	0	0
Migration of Birds	15	0	0
Plankton and Physical Conditions of the English Channel	40	0	0
Zoology of the Sandwich Islands	100	0	0
Coral Reefs of the Indian Region	30	0	0
Physical and Chemical Constants of Sea-Water	100	0	0
Future Dealings in Raw Produce	2	10	0
Silchester Excavation	10	0	0
Ethnological Survey of Canada	50	0	0
New Edition of 'Anthropological Notes and Queries'	40	0	0
Photographs of Anthropological Interest	10	0	0
Mental and Physical Condition of Children in Schools	5	0	0
Ethnography of the Malay Peninsula	25	0	0
Physiological Effects of Peptone	20	0	0
Comparative Histology of Suprarenal Capsules	20	0	0
Comparative Histology of Cerebral Cortex	5	0	0
Electrical Changes in Mammalian Nerves	20	0	0
Vascular Supply of Secreting Glands	10	0	0
Fertilisation in Phæophyceæ	20	0	0
Corresponding Societies Com.	20	0	0
	£1,072	10	0

1901.

	£	s.	d.
Electrical Standards	45	0	0
Seismological Observations	75	0	0
Wave-length Tables	4	14	0
Isomorphous Sulphonic Derivatives of Benzene	35	0	0
Life-zones in British Carboniferous Rocks	20	0	0
Underground Water of North-west Yorkshire	50	0	0
Exploration of Irish Caves	15	0	0
Table at the Zoological Station, Naples	100	0	0
Table at the Biological Laboratory, Plymouth	20	0	0
Index Generum et Specierum Animalium	75	0	0
Migration of Birds	10	0	0
Terrestrial Surface Waves	5	0	0
Changes of Land-level in the Phlegræan Fields	50	0	0
Legislation regulating Women's Labour	15	0	0
Small Screw Gauge	45	0	0
Resistance of Road Vehicles to Traction	75	0	0
Silchester Excavation	10	0	0
Ethnological Survey of Canada	30	0	0
Anthropological Teaching	5	0	0
Exploration in Crete	145	0	0
Physiological Effects of Peptone	30	0	0
Chemistry of Bone Marrow	5	15	11
Suprarenal Capsules in the Rabbit	5	0	0
Fertilisation in Phæophyceæ	15	0	0
Morphology, Ecology, and Taxonomy of Podostemaceæ	20	0	0
Corresponding Societies Committee	15	0	0
	£920	9	11

1902.

	£	s.	d.
Electrical Standards	40	0	0
Seismological Observations	35	0	0
Investigation of the Upper Atmosphere by means of Kites	75	0	0
Magnetic Observations at Falmouth	80	0	0
Relation between Absorption Spectra and Organic Substances	20	0	0
Wave-length Tables	5	0	0
Life-zones in British Carboniferous Rocks	10	0	0
Exploration of Irish Caves	45	0	0
Table at the Zoological Station, Naples	100	0	0
Index Generum et Specierum Animalium	100	0	0
Migration of Birds	15	0	0
Structure of Coral Reefs of Indian Ocean	50	0	0

	£	s.	d.
Compound Ascidians of the Clyde Area	25	0	0
Terrestrial Surface Waves ...	15	0	0
Legislation regulating Women's Labour	30	0	0
Small Screw Gauge	20	0	0
Resistance of Road Vehicles to Traction	50	0	0
Ethnological Survey of Canada	15	0	0
Age of Stone Circles	30	0	0
Exploration in Crete	100	0	0
Anthropometric Investigation of Native Egyptian Soldiers	15	0	0
Excavations on the Roman Site at Gelligaer	5	0	0
Changes in Hæmoglobin	15	0	0
Work of Mammalian Heart under Influence of Drugs...	20	0	0
Investigation of the Cyanophyceæ	10	0	0
Reciprocal Influence of Universities and Schools	5	0	0
Conditions of Health essential to carrying on Work in Schools	2	0	0
Corresponding Societies Com.	15	0	0
	£947	0	0

1903.

	£	s.	d.
Electrical Standards	35	0	0
Seismological Observations...	40	0	0
Investigation of the Upper Atmosphere by means of Kites	75	0	0
Magnetic Observations at Falmouth	40	0	0
Study of Hydro-aromatic Substances	20	0	0
Erratic Blocks	10	0	0
Exploration of Irish Caves ...	40	0	0
Underground Waters of Northwest Yorkshire	40	0	0
Life-zones in British Carboniferous Rocks	5	0	0
Geological Photographs	10	0	0
Table at the Zoological Station at Naples	100	0	0
Index Generum et Specierum Animalium	100	0	0
Tidal Bore, Sea Waves, and Beaches	15	0	0
Scottish National Antarctic Expedition	50	0	0
Legislation affecting Women's Labour	25	0	0
Researches in Crete	100	0	0
Age of Stone Circles	3	13	2
Anthropometric Investigation	5	0	0
Anthropometry of the Todas and other Tribes of Southern India	50	0	0
The State of Solution of Proteids	20	0	0
Investigation of the Cyanophyceæ	25	0	0
Respiration of Plants	12	0	0
Conditions of Health essential for School Instruction	5	0	0
Corresponding Societies Com.	20	0	0
	£845	13	2

1904.

	£	s.	d.
Seismological Observations...	40	0	0
Investigation of the Upper Atmosphere by means of Kites	50	0	0
Magnetic Observations at Falmouth	60	0	0
Wave-length Tables of Spectra	10	0	0
Study of Hyro-aromatic Substances	25	0	0
Erratic Blocks	10	0	0
Life-zones in British Carboniferous Rocks	35	0	0
Fauna and Flora of the Trias	10	0	0
Investigation of Fossiliferous Drifts	50	0	0
Table at the Zoological Station, Naples	100	0	0
Index Generum et Specierum Animalium	60	0	0
Development in the Frog	15	0	0
Researches on the Higher Crustacea	15	0	0
British and Foreign Statistics of International Trade	25	0	0
Resistance of Road Vehicles to Traction	90	0	0
Researches in Crete	100	0	0
Researches in Glastonbury Lake Village	25	0	0
Anthropometric Investigation of Egyptian Troops	8	10	0
Excavations on Roman Sites in Britain	25	0	0
The State of Solution of Proteids	20	0	0
Metabolism of Individual Tissues	40	0	0
Botanical Photographs	4	8	11
Respiration of Plants	15	0	0
Experimental Studies in Heredity	35	0	0
Corresponding Societies Committee	20	0	0
	£887	18	11

1905.

	£	s.	d.
Electrical Standards	40	0	0
Seismological Observations	40	0	0
Investigation of the Upper Atmosphere by means of Kites	40	0	0
Magnetic Observations at Falmouth	50	0	0
Wave-length Tables of Spectra	5	0	0
Study of Hydro-aromatic Substances	25	0	0
Dynamic Isomerism	20	0	0
Aromatic Nitramines	25	0	0
Fauna and Flora of the British Trias	10	0	0
Table at the Zoological Station, Naples	100	0	0
Index Generum et Specierum Animalium	75	0	0
Development in the Frog	10	0	0
Investigations in the Indian Ocean	150	0	0
Trade Statistics	4	4	8
Researches in Crete	75	0	0
Anthropometric Investigations on Egyptian Troops	10	0	0
Excavations on Roman Sites in Britain	10	0	0
Anthropometric Investigations	10	0	0
Age of Stone Circles	30	0	0
The State of Solution of Proteids	20	0	0
Metabolism of Individual Tissues	30	0	0
Ductless Glands	40	0	0
Botanical Photographs	3	17	6
Physiology of Heredity	35	0	0
Structure of Fossil Plants	50	0	0
Corresponding Societies Committee	20	0	0
	£928	2	2

General Meetings.

AT THE CITY HALL, CAPE TOWN.

On Tuesday, August 15, at 8.30 P.M., a letter from the retiring President, the Right Hon. A. J. Balfour, D.C.L., LL.D., M.P., F.R.S., having been read, Professor G. H. Darwin, M.A., LL.D., Ph.D., F.R.S., assumed the office of President, and delivered the first part of an Address, for which see p. 3.

On Wednesday, August 16, at 8 P.M., a Reception was held by the Mayor.

On Thursday, August 17, at 8.30 P.M., Professor E. B. Poulton, F.R.S., delivered a Lecture on 'W. J. Burchell's Discoveries in South Africa.'

On Friday, August 18, at 8.30 P.M., Mr. C. Vernon Boys, F.R.S., delivered a Lecture on 'Some Surface Actions of Fluids.'

AT JOHANNESBURG.

On Monday, August 28, at 8.30 P.M., the Mayor and Town Council held a Reception at the Wanderers' Club.

On Tuesday, August 29, at 8.30 P.M., Professor W. E. Ayrton, F.R.S., delivered a Lecture on 'The Distribution of Power' at St. Mary's Hall.

On Wednesday, August 30, at 8.30 P.M., at St. Mary's Hall, Professor Darwin delivered the concluding part of his Address.

On Thursday, August 31, at 8.30 P.M., Professor J. O. Arnold delivered a Lecture on 'Steel as an Igneous Rock' at St. Mary's Hall.

On Friday, September 1, at 5 P.M., the concluding General Meeting took place in the Municipal Buildings, when the Proceedings of the General Committee and the Grants of Money for Scientific Purposes were explained to the Members.

The Meeting was then adjourned to York.

*** *See* APPENDIX for a detailed account of the Meeting in South Africa texts of Addresses of Welcome, notices of Lectures, and information in regard to the foundation of a South Africa Medal.

PRESIDENT'S ADDRESS.

ADDRESS

BY

Professor G. H. DARWIN, M.A., LL.D., Ph.D., F.R.S.

PRESIDENT.

Bartholomeu Diaz, the discoverer of the Cape of Storms, spent sixteen months on his voyage, and the little flotilla of Vasco da Gama, sailing from Lisbon on July 8, 1497, only reached the Cape in the middle of November. These bold men, sailing in their puny fishing smacks to unknown lands, met the perils of the sea and the attacks of savages with equal courage. How great was the danger of such a voyage may be gathered from the fact that less than half the men who sailed with da Gama lived to return to Lisbon. Four hundred and eight years have passed since that voyage, and a ship of 13,000 tons has just brought us here, in safety and luxury, in but little more than a fortnight.

How striking are the contrasts presented by these events! On the one hand compare the courage, the endurance, and the persistence of the early navigators with the little that has been demanded of us; on the other hand consider how much man's power over the forces of Nature has been augmented during the past four centuries. The capacity for heroism is probably undiminished, but certainly the occasions are now rarer when it is demanded of us. If we are heroes, at least but few of us ever find it out, and, when we read stories of ancient feats of courage, it is hard to prevent an uneasy thought that, notwithstanding our boasted mechanical inventions, we are perhaps degenerate descendants of our great predecessors.

Yet the thought that to-day is less romantic and less heroic than yesterday has its consolation, for it means that the lot of man is easier than it was. Mankind, indeed, may be justly proud that this improvement has been due to the successive efforts of each generation to add to the heritage of knowledge handed down to it by its predecessors, whereby we have been born to the accumulated endowment of centuries of genius and labour.

I am told that in the United States the phrase 'I want to know' has

lost the simple meaning implied by the words, and has become a mere exclamation of surprise. Such a conventional expression could hardly have gained currency except amongst a people who aspire to knowledge. The dominance of the European race in America, Australasia, and South Africa has no doubt arisen from many causes, but amongst these perhaps the chief one is that not only do 'we want to know,' but also that we are determined to find out. And now within the last quarter of a century we have welcomed into the ranks of those who 'want to know' an oriental race, which has already proved itself strong in the peaceful arts of knowledge.

I take it, then, that you have invited us because you want to know what is worth knowing; and we are here because we want to know you, to learn what you have to tell us, and to see that South Africa of which we have heard so much.

The hospitality which you are offering us is so lavish, and the journeys which you have organised are so extensive, that the cynical observer might be tempted to describe our meeting as the largest picnic on record. Although we intend to enjoy our picnic with all our hearts, yet I should like to tell the cynic, if he is here, that perhaps the most important object of these conferences is the opportunity they afford for personal intercourse between men of like minds who live at the remotest corners of the earth.

We shall pass through your land with the speed and the voracity of a flight of locusts; but, unlike the locust, we shall, I hope, leave behind us permanent fertilisation in the form of stimulated scientific and educational activity. And this result will ensue whether or not we who have come from Europe are able worthily to sustain the lofty part of prophets of science. We shall try our best to play to your satisfaction on the great stage upon which you call on us to act, and if when we are gone you shall, amongst yourselves, pronounce the performance a poor one, yet the fact will remain, that this meeting has embodied in a material form the desire that the progress of this great continent shall not be merely material; and such an aspiration secures its own fulfilment. However small may be the tangible results of our meeting, we shall always be proud to have been associated with you in your efforts for the advancement of science.

We do not know whether the last hundred years will be regarded for ever as the *sæculum mirabile* of discovery, or whether it is but the prelude to yet more marvellous centuries. To us living men, who scarcely pass a year of our lives without witnessing some new marvel of discovery or invention, the rate at which the development of knowledge proceeds is truly astonishing; but from a wider point of view the scale of time is relatively unimportant, for the universe is leisurely in its procedure. Whether the changes which we witness be fast or slow, they form a part of a long sequence of events which begin in some past of immeasurable remoteness and tend to some end which we cannot fore-

see. It must always be profoundly interesting to the mind of man to trace successive cause and effect in the chain of events which make up the history of the earth and all that lives on it, and to speculate on the origin and future fate of animals, and of planets, suns, and stars. I shall try, then, to set forth in my address some of the attempts which have been made to formulate Evolutionary speculation. This choice of a subject has moreover been almost forced on me by the scope of my own scientific work, and it is, I think, justified by the name which I bear. It will be my fault and your misfortune if I fail to convey to you some part of the interest which is naturally inherent in such researches.

The man who propounds a theory of evolution is attempting to reconstruct the history of the past by means of the circumstantial evidence afforded by the present. The historian of man, on the other hand, has the advantage over the evolutionist in that he has the written records of the past on which to rely. The discrimination of the truth from amongst discordant records is frequently a work demanding the highest qualities of judgment; yet when this end is attained it remains for the historian to convert the arid skeleton of facts into a living whole by clothing it with the flesh of human motives and impulses. For this part of his task he needs much of that power of entering into the spirit of other men's lives which goes to the making of a poet. Thus the historian should possess not only the patience of the man of science in the analysis of facts, but also the imagination of the poet to grasp what the facts have meant. Such a combination is rarely to be found in equal perfection on both sides, and it would not be hard to analyse the works of great historians so as to see which quality was predominant in each of them.

The evolutionist is spared the surpassing difficulty of the human element, yet he also needs imagination, although of a different character from that of the historian. In its lowest form his imagination is that of the detective who reconstructs the story of a crime; in its highest it demands the power of breaking loose from all the trammels of convention and education, and of imagining something which has never occurred to the mind of man before. In every case the evolutionist must form a theory for the facts before him, and the great theorist is only to be distinguished from the fantastic fool by the sobriety of his judgment—a distinction, however, sufficient to make one rare and the other only too common.

The test of a scientific theory lies in the number of facts which it groups into a connected whole; it ought besides to be fruitful in pointing the way to the discovery and co-ordination of new and previously unsuspected facts. Thus a good theory is in effect a cyclopædia of knowledge, susceptible of indefinite extension by the addition of supplementary volumes.

Hardly any theory is all true, and many are not all false. A theory may be essentially at fault and yet point the way to truth

and so justify its temporary existence. We should not, therefore, totally reject one or other of two rival theories on the ground that they seem, with our present knowledge, mutually inconsistent, for it is likely that both may contain important elements of truth. The theories of which I shall have to speak hereafter may often appear discordant with one another according to our present lights. Yet we must not scruple to pursue the several divergent lines of thought to their logical conclusions, relying on future discovery to eliminate the false and to reconcile together the truths which form part of each of them.

In the mouths of the unscientific evolution is often spoken of as almost synonymous with the evolution of the various species of animals on the earth, and this again is sometimes thought to be practically the same thing as the theory of Natural Selection. Of course those who are conversant with the history of scientific ideas are aware that a belief in the gradual and orderly transformation of Nature, both animate and inanimate, is of great antiquity.

We may liken the facts on which theories of evolution are based to a confused heap of beads, from which a keen-sighted searcher after truth picks out and strings together a few which happen to catch his eye, as possessing certain resemblances. Until recently, theories of evolution in both realms of Nature were partial and discontinuous, and the chains of facts were correspondingly short and disconnected. At length the theory of Natural Selection, by formulating the cause of the divergence of forms in the organic world from the parental stock, furnished the naturalist with a clue by which he examined the disordered mass of facts before him, and he was thus enabled to go far in deducing order where chaos had ruled before, but the problem of reducing the heap to perfect order will probably baffle the ingenuity of the investigator for ever.

So illuminating has been this new idea that, as the whole of Nature has gradually been re-examined by its aid, thousands of new facts have been brought to light, and have been strung in due order on the necklace of knowledge. Indeed the transformation resulting from the new point of view has been so far-reaching as almost to justify the misapprehension of the unscientific as to the date when the doctrines of evolution first originated in the mind of man.

It is not my object, nor indeed am I competent, to examine the extent to which the Theory of Natural Selection has needed modification since it was first formulated by my father and Wallace. But I am surely justified in maintaining that the general principle holds its place firmly as a permanent acquisition to modes of thought.

Evolutionary doctrines concerning inanimate nature, although of much older date than those which concern life, have been profoundly affected by the great impulse of which I have spoken. It has thus come about that the origin and history of the chemical elements and of stellar systems now occupy a far larger space in the scientific mind than was formerly the case. The subject which I shall discuss to-night is the extent to which

ideas, parallel to those which have done so much towards elucidating the problems of life, hold good also in the world of matter ; and I believe that it will be possible to show that in this respect there exists a resemblance between the two realms of nature, which is not merely fanciful. It is proper to add that as long ago as 1873 Baron Karl du Prel discussed the same subject, from a similar point of view, in a book entitled 'The Struggle for Life in the Heavens.'[1]

Although inanimate matter moves under the action of forces which are incomparably simpler than those governing living beings, yet the problems of the physicist and the astronomer are scarcely less complex than those which present themselves to the biologist. The mystery of life remains as impenetrable as ever, and in his evolutionary speculations the biologist does not attempt to explain life itself, but, adopting as his unit the animal as a whole, discusses its relationships to other animals and to the surrounding conditions. The physicist, on the other hand, is irresistibly impelled to form theories as to the intimate constitution of the ultimate parts of matter, and he desires further to piece together the past histories and the future fates of planets, stars, and nebulæ. If then the speculations of the physicist seem in some respects less advanced than those of the biologist, it is chiefly because he is more ambitious in his aims. Physicists and astronomers have not yet found their Johannesburg or Kimberley ; but although we are still mere prospectors, I am proposing to show you some of the dust and diamonds which we have already extracted from our surface mines.

The fundamental idea in the theory of Natural Selection is the persistence of those types of life which are adapted to their surrounding conditions, and the elimination by extermination of ill-adapted types. The struggle for life amongst forms possessing a greater or less degree of adaptation to slowly varying conditions is held to explain the gradual transmutation of species. Although a different phraseology is used when we speak of the physical world, yet the idea is essentially the same.

The point of view from which I wish you to consider the phenomena of the world of matter may be best explained if, in the first instance, I refer to political institutions, because we all understand, or fancy we understand, something of politics, whilst the problems of physics are commonly far less familiar to us. This illustration will have a further advantage in that it will not be a mere parable, but will involve the fundamental conception of the nature of evolution.

The complex interactions of man with man in a community are usually described by such comprehensive terms as the State, the Commonwealth, or the Government. Various States differ widely in their constitution and in the degree of the complexity of their organisation, and we classify them by various general terms, such as autocracy, aristocracy, or democracy, which express somewhat loosely their leading characteristics.

[1] *Der Kampf um's Dasein am Himmel* (zweite Auflage), Denicke, Berlin, 1876.

But, for the purpose of showing the analogy with physics, we need terms of wider import than those habitually used in politics. All forms of the State imply inter-relationship in the actions of men, and action implies movement. Thus the State may be described as a configuration or arrangement of a community of men; or we may say that it implies a definite mode of motion of man—that is to say an organised scheme of action of man on man. Political history gives an account of the gradual changes in such configurations or modes of motion of men as have possessed the quality of persistence or of stability to resist the disintegrating influence of surrounding circumstances.

In the world of life the naturalist describes those forms which persist as species; similarly the physicist speaks of stable configurations or modes of motion of matter; and the politician speaks of States. The idea at the base of all these conceptions is that of stability, or the power of resisting disintegration. In other words, the degree of persistence or permanence of a species, of a configuration of matter, or of a State depends on the perfection of its adaptation to its surrounding conditions.

If we trace the history of a State we find the degree of its stability gradually changing, slowly rising to a maximum, and then slowly declining. When it falls to nothing a revolution ensues, and a new form of government is established. The new mode of motion or government has at first but slight stability, but it gradually acquires strength and permanence, until in its turn the slow decay of stability leads on to a new revolution.

Such crises in political history may give rise to a condition in which the State is incapable of perpetuation by transformation. This occurs when a savage tribe nearly exterminates another tribe and leads the few survivors into slavery; the previous form of government then becomes extinct.

The physicist, like the biologist and the historian, watches the effect of slowly varying external conditions; he sees the quality of persistence or stability gradually decaying until it vanishes, when there ensues what is called, in politics, a revolution.

These considerations lead me to express a doubt whether biologists have been correct in looking for continuous transformation of species. Judging by analogy we should rather expect to find slight continuous changes occurring during a long period of time, followed by a somewhat sudden transformation into a new species, or by rapid extinction.[1] However this may be, when the stability of a mode of motion vanishes, the physicist either finds that it is replaced by a new persistent type of

[1] If we may illustrate this graphically, I suggest that the process of transformation may be represented by long lines of gentle slope, followed by shorter lines of steeper slope. The alternative is a continuous uniform slope of change. If the former view is correct, it would explain why it should not be easy to detect specific change in actual operation. Some of my critics have erroneously thought that I advocate specific change *per saltum*.

motion adapted to the changed conditions, or perhaps that no such transformation is possible and that the mode of motion has become extinct. The evanescent type of animal life has often been preserved for us, fossilised in geological strata ; the evanescent form of government is preserved in written records or in the customs of savage tribes ; but the physicist has to pursue his investigations without such useful hints as to the past.

The time-scale in the transmutation of species of animals is furnished by the geological record, although it is not possible to translate that record into years. As we shall see hereafter, the time needed for a change of type in atoms or molecules may be measured by millionths of a second, while in the history of the stars continuous changes may occupy millions of years. Notwithstanding this gigantic contrast in speed, yet the process involved seems to be essentially the same.

It is hardly too much to assert that, if the conditions which determine stability of motion could be accurately formulated throughout the universe, the past history of the cosmos and its future fate would be unfolded. How indefinitely far we stand removed from such a state of knowledge will become abundantly clear from the remainder of my address.

The study of stability and instability then furnishes the problems which the physicist and biologist alike attempt to solve. The two classes of problems differ principally in the fact that the conditions of the world of life are so incomparably more intricate than those of the world of matter that the biologist is compelled to abandon the attempt to determine the absolute amount of the influence of the various causes which have affected the existence of species. His conclusions are merely qualitative and general, and he is almost universally compelled to refrain from asserting even in general terms what are the reasons which have rendered one form of animal life stable and persistent, and another unstable and evanescent.

On the other hand, the physicist, as a general rule, does not rest satisfied unless he obtains a quantitative estimate of various causes and effects on the systems of matter which he discusses. Yet there are some problems of physical evolution in which the conditions are so complex that the physicist is driven, as is the biologist, to rest satisfied with qualitative rather than quantitative conclusions. But he is not content with such crude conclusions except in the last resort, and he generally prefers to proceed by a different method.

The mathematician mentally constructs an ideal mechanical system or model, which is intended to represent in its leading features the system he wants to examine. It is often a task of the utmost difficulty to devise such a model, and the investigator may perchance unconsciously drop out as unimportant something which is really essential to represent actuality. He next examines the conditions of his ideal system, and determines, if he can, all the possible stable and unstable configurations, together with the circumstances which will cause transitions from one to the other.

Even when the working model has been successfully imagined, this latter task may often overtax the powers of the mathematician. Finally it remains for him to apply his results to actual matter, and to form a judgment of the extent to which it is justifiable to interpret Nature by means of his results.

The remainder of my address will be occupied by an account of various investigations which will illustrate the principles and methods which I have now explained in general terms.

The fascinating idea that matter of all kinds has a common substratum is of remote antiquity. In the Middle Ages the alchemists, inspired by this idea, conceived the possibility of transforming the baser metals into gold. The sole difficulty seemed to them the discovery of an appropriate series of chemical operations. We now know that they were always indefinitely far from the goal of their search, yet we must accord to them the honour of having been the pioneers of modern chemistry.

The object of alchemy, as stated in modern language, was to break up or dissociate the atoms of one chemical element into its component parts, and afterwards to reunite them into atoms of gold. Although even the dissociative stage of the alchemistic problem still lies far beyond the power of the chemist, yet modern researches seem to furnish a sufficiently clear idea of the structure of atoms to enable us to see what would have to be done to effect a transformation of elements. Indeed, in the complex changes which are found to occur spontaneously in uranium, radium, and the allied metals we are probably watching a spontaneous dissociation and transmutation of elements.

Natural Selection may seem, at first sight, as remote as the poles asunder from the ideas of the alchemist, yet dissociation and transmutation depend on the instability and regained stability of the atom, and the survival of the stable atom depends on the principle of Natural Selection.

Until some ten years ago the essential diversity of the chemical elements was accepted by the chemist as an ultimate fact, and indeed the very name of atom, or that which cannot be cut, was given to what was supposed to be the final indivisible portion of matter. The chemist thus proceeded in much the same way as the biologist who, in discussing evolution, accepts the species as his working unit. Accordingly, until recently the chemist discussed working models of matter of atomic structure, and the vast edifice of modern chemistry has been built with atomic bricks.

But within the last few years the electrical researches of Lenard, Röntgen, Becquerel, the Curies, of my colleagues Larmor and Thomson, and of a host of others, have shown that the atom is not indivisible, and a flood of light has been thrown thereby on the ultimate constitution of

matter. Amongst all these fertile investigators it seems to me that Thomson stands pre-eminent, because it is principally through him that we are to-day in a better position for picturing the structure of an atom than was ever the case before.

Even if I had the knowledge requisite for a complete exposition of these investigations, the limits of time would compel me to confine myself to those parts of the subject which bear on the constitution and origin of the elements.

It has been shown, then, that the atom, previously supposed to be indivisible, really consists of a large number of component parts. By various convergent lines of experiment it has been proved that the simplest of all atoms, namely that of hydrogen, consists of about 800 separate parts; while the number of parts in the atom of the denser metals must be counted by tens of thousands. These separate parts of the atom have been called corpuscles or electrons, and may be described as particles of negative electricity. It is paradoxical, yet true, that the physicist knows more about these ultra-atomic corpuscles and can more easily count them than is the case with the atoms of which they form the parts.

The corpuscles, being negatively electrified, repel one another just as the hairs on a person's head mutually repel one another when combed with a vulcanite comb. The mechanism is as yet obscure whereby the mutual repulsion of the negative corpuscles is restrained from breaking up the atom, but a positive electrical charge, or something equivalent thereto, must exist in the atom, so as to prevent disruption. The existence in the atom of this community of negative corpuscles is certain, and we know further that they are moving with speeds which may be in some cases comparable to the velocity of light, namely, 200,000 miles a second. But the mechanism whereby they are held together in a group is hypothetical.

It is only just a year ago that Thomson suggested, as representing the atom, a mechanical or electrical model whose properties could be accurately examined by mathematical methods. He would be the first to admit that his model is at most merely a crude representation of actuality, yet he has been able to show that such an atom must possess mechanical and electrical properties which simulate, with what Whetham describes as 'almost Satanic exactness,' some of the most obscure and yet most fundamental properties of the chemical elements. 'Se non è vero, è ben trovato,' and we are surely justified in believing that we have the clue which the alchemists sought in vain.

Thomson's atom consists of a globe homogeneously charged with positive electricity, inside which there are one or more thousands of corpuscles of negative electricity, revolving in regular orbits with great velocities. Since two electrical charges repel each other if they are of the same kind, and attract each other if they are of opposite kinds, the corpuscles mutually repel one another, but all are attracted by the positive electricity

distributed throughout the globe. The forces called into play by these electrical interactions are clearly very complicated, and you will not be surprised to learn that Thomson found himself compelled to limit his detailed examination of the model atom to one containing about seventy corpuscles. It is indeed a triumph of mathematical power to have determined the mechanical conditions of such a miniature planetary system as I have described.

It appears that in general there are definite arrangements of the orbits in which the corpuscles must revolve, if they are to be persistent or stable in their motions. But the number of corpuscles in such a community is not absolutely fixed. It is easy to see that we might add a minor planet, or indeed half a dozen minor planets, to the solar system without any material derangement of the whole; but it would not be possible to add a hundred planets with an aggregate mass equal to that of Jupiter without disorganisation of the solar system. So also we might add or subtract from an atom three or four corpuscles from a system containing a thousand corpuscles moving in regular orbits without any profound derangement. As each arrangement of orbits corresponds to the atom of a distinct element, we may say that the addition or subtraction of a few corpuscles to the atom will not effect a transmutation of elements. An atom which has a deficiency of its full complement of corpuscles, which it will be remembered are negative, will be positively electrified, while one with an excess of corpuscles will be negatively electrified. I have referred to the possibility of a deficiency or excess of corpuscles because it is important in Thomson's theory; but, as it is not involved in the point of view which I wish to take, I will henceforth only refer to the normal or average number in any arrangement of corpuscles. Accordingly we may state that definite numbers of corpuscles are capable of association in stable communities of definite types.

An infinite number of communities are possible, possessing greater or lesser degrees of stability. Thus the corpuscles in one such community might make thousands of revolutions in their orbits before instability declared itself; such an atom might perhaps last for a long time as estimated in millionths of seconds, but it must finally break up and the corpuscles must disperse or rearrange themselves after the ejection of some of their number. We are thus led to conjecture that the several chemical elements represent those different kinds of communities of corpuscles which have proved by their stability to be successful in the struggle for life. If this is so, it is almost impossible to believe that the successful species have existed for all time, and we must hold that they originated under conditions about which I must forbear to follow Sir Norman Lockyer in speculating.[1]

But if the elements were not eternal in the past, we must ask whether there is reason to believe that they will be eternal in the

[1] *Inorganic Evolution*, Macmillan, 1900.

future. Now, although the conception of the decay of an element and its spontaneous transmutation into another element would have seemed absolutely repugnant to the chemist until recently, yet analogy with other moving systems seems to suggest that the elements are not eternal.

At any rate it is of interest to pursue to its end the history of the model atom which has proved to be so successful in imitating the properties of matter. The laws which govern electricity in motion indicate that such an atom must be radiating or losing energy, and therefore a time must come when it will run down, as a clock does. When this time comes it will spontaneously transmute itself into an element which needs less energy than was required in the former state. Thomson conceives that an atom might be constructed after his model so that its decay should be very slow. It might, he thinks, be made to run for a million years or more, but it would not be eternal.

Such a conclusion is in absolute contradiction to all that was known of the elements until recently, for no symptoms of decay are perceived, and the elements existing in the solar system must already have lasted for millions of years. Nevertheless, there is good reason to believe that in radium, and in other elements possessing very complex atoms, we do actually observe that break-up and spontaneous rearrangement which constitute a transmutation of elements.

It is impossible as yet to say how science will solve this difficulty, but future discovery in this field must surely prove deeply interesting.[1] It may well be that the train of thought which I have sketched will ultimately profoundly affect the material side of human life, however remote it may now seem from our experiences of daily life.

I have not as yet made any attempt to represent the excessive minuteness of the corpuscles, of whose existence we are now so confident; but, as an introduction to what I have to speak of next, it is necessary to do so. To obtain any adequate conception of their size we must betake ourselves to a scheme of threefold magnification. Lord Kelvin has shown that, if a drop of water were magnified to the size of the earth, the molecules of water would be of a size intermediate between that of a cricket-ball and of a marble. Now each molecule contains three atoms, two being of hydrogen and one of oxygen. The molecular system probably presents some sort of analogy with that of a triple star; the three atoms, replacing the stars, revolving about one another in some sort of dance which cannot be exactly described. I doubt whether it is possible to say how large a part of the space occupied by the whole molecule is occupied by the atoms; but perhaps the atoms bear to the molecule some such relationship as the molecule to the drop of water referred to. Finally, the corpuscles may stand to the atom in a similar scale of magnitude. Accordingly a threefold magnification would be needed to bring these

[1] The view that the elements are not absolutely permanent seems to be gaining ground. See correspondence in *Nature*: D. Murray, December 7; Soddy and Campbell, December 14, 1905.

ultimate parts of the atom within the range of our ordinary scales of measurement.

I have already considered what would be observed under the triply powerful microscope, and must now return to the intermediate stage of magnification, in which we consider those communities of atoms which form molecules. This is the field of research of the chemist. Although prudence would tell me that it would be wiser not to speak of a subject of which I know so little, yet I cannot refrain from saying a few words.

The community of atoms in water has been compared with a triple star, but there are others known to the chemist in which the atoms are to be counted by fifties and hundreds, so that they resemble constellations.

I conceive that here again we meet with conditions similar to those which we have supposed to exist in the atom. Communities of atoms are called chemical combinations, and we know that they possess every degree of stability. The existence of some is so precarious that the chemist in his laboratory can barely retain them for a moment; others are so stubborn that he can barely break them up. In this case dissociation and reunion into new forms of communities are in incessant and spontaneous progress throughout the world. The more persistent or more stable combinations succeed in their struggle for life, and are found in vast quantities, as in the cases of common salt and of the combinations of silicon. But no one has ever found a mine of gun-cotton, because it has so slight a power of resistance. If, through some accidental collocation of elements, a single molecule of gun-cotton were formed, it would have but a short life.

Stability is, further, a property of relationship to surrounding conditions; it denotes adaptation to environment. Thus salt is adapted to the struggle for existence on the earth, but it cannot withstand the severer conditions which exist in the sun.

Thus far we have been concerned with the almost inconceivably minute, and I now propose to show that similar conditions prevail on a larger scale.

Many geological problems might well be discussed from my present point of view, yet I shall pass them by, and shall proceed at once to Astronomy, beginning with the smallest cosmical scale of magnitude, and considering afterwards the larger celestial phenomena.

The problems of cosmical evolution are so complicated that it is well to conduct the attack in various ways at the same time. Although the several theories may seem to some extent discordant with one another, yet, as I have already said, we ought not to scruple to carry each to its logical conclusion. We may be confident that in time the false will be eliminated from each theory, and when the true alone remains the reconciliation of apparent disagreements will have become obvious.

The German astronomer Bode long ago propounded a simple empirical

law concerning the distances at which the several planets move about the sun. It is true that the planet Neptune, discovered subsequently, was found to be considerably out of the place which would be assigned to it by Bode's law, yet his formula embraces so large a number of cases with accuracy that we are compelled to believe that it arises in some manner from the primitive conditions of the planetary system.

The explanation of the causes which have led to this simple law as to the planetary distances presents an interesting problem, and, although it is still unsolved, we may obtain some insight into its meaning by considering what I have called a working model of ideal simplicity.

Imagine then a sun round which there moves in a circle a single large planet. I will call this planet Jove, because it may be taken as a representative of our largest planet, Jupiter. Suppose next that a meteoric stone or small planet is projected in any perfectly arbitrary manner in the same plane in which Jove is moving; then we ask how this third body will move. The conditions imposed may seem simple, yet the problem has so far overtaxed the powers of the mathematician that nothing approaching a general answer to our question has yet been given. We know, however, that under the combined attractions of the sun and Jove the meteoric stone will in general describe an orbit of extraordinary complexity, at one time moving slowly at a great distance from both the sun and Jove, at other times rushing close past one or other of them. As it grazes past Jove or the sun it may often but just escape a catastrophe, but a time will come at length when it runs its chances too fine and comes into actual collision. The individual career of the stone is then ended by absorption, and of course by far the greater chance is that it will find its Nirvana by absorption in the sun.

Next let us suppose that instead of one wandering meteoric stone or minor planet there are hundreds of them, moving initially in all conceivable directions. Since they are all supposed to be very small, their mutual attractions will be insignificant, and they will each move almost as though they were influenced only by the sun and Jove. Most of these stones will be absorbed by the sun, and the minority will collide with Jove.

When we inquire how long the career of a stone may be, we find that it depends on the direction and speed with which it is started, and that by proper adjustment the delay of the final catastrophe may be made as long as we please. Thus by making the delay indefinitely long we reach the conception of a meteoric stone which moves so as never to come into collision with either body.

There are, therefore, certain perpetual orbits in which a meteoric stone or minor planet may move for ever without collision. But when such an immortal career has been discovered for our minor planet, it still remains to discover whether the slightest possible departure from the prescribed orbit will become greater and greater and ultimately lead to a collision with the sun or Jove, or whether the body will travel so as to cross and recross the exact perpetual orbit, always remaining close to it.

If the slightest departure inevitably increases as time goes on, the orbit is unstable; if, on the other hand, it only leads to a slight waviness in the path described, it is stable.

We thus arrive at another distinction: there are perpetual orbits, but some, and indeed most, are unstable, and these do not offer an immortal career for a meteoric stone; and there are other perpetual orbits which are stable or persistent. The unstable ones are those which succumb in the struggle for life, and the stable ones are the species adapted to their environment.

If, then, we are given a system of a sun and large planet, together with a swarm of small bodies moving in all sorts of ways, the sun and planet will grow by accretion, gradually sweeping up the dust and rubbish of the system, and there will survive a number of small planets and satellites moving in certain definite paths. The final outcome will be an orderly planetary system in which the various orbits are arranged according to some definite law.

But the problem presented even by a system of such ideal simplicity is still far from having received a complete solution. No general plan for determining perpetual orbits has yet been discovered, and the task of discriminating the stable from the unstable is arduous. But a beginning has been made in the determination of some of the zones surrounding the sun and Jove in which stable orbits are possible, and others in which they are impossible. There is hardly room for doubt that if a complete solution for our solar system were attainable, we should find that the orbits of the existing planets and satellites are numbered amongst the stable perpetual orbits, and should thus obtain a rigorous mechanical explanation of Bode's law concerning the planetary distances.

It is impossible not to be struck by the general similarity between the problem presented by the corpuscles moving in orbits in the atom, and that of the planets and satellites moving in a planetary system. It may not, perhaps, be fanciful to imagine that some general mathematical method devised for solving a problem of cosmical evolution may find another application to miniature atomic systems, and may thus lead onward to vast developments of industrial mechanics. Science, however diverse its aims, is a whole, and men of science do well to impress on the captains of industry that they should not look askance on those branches of investigation which may seem for the moment far beyond any possibility of practical utility.

You will remember that I discussed the question as to whether the atomic communities of corpuscles could be regarded as absolutely eternal, and that I said that the analogy of other moving systems pointed to their ultimate mortality. Now the chief analogy which I had in my mind was that of a planetary system.

The orbits of which I have spoken are only perpetual when the bodies are infinitesimal in mass, and meet with no resistance as they move. Now the infinitesimal body does not exist, and both Lord Kelvin and

Poincaré concur in holding that disturbance will ultimately creep into any system of bodies moving even in so-called stable orbits; and this is so even apart from the resistance offered to the moving bodies by any residual gas there may be scattered through space. The stability is therefore only relative, and a planetary system contains the seeds of its own destruction. But this ultimate fate need not disturb us either practically or theoretically, for the solar system contains in itself other seeds of decay which will probably bear fruit long before the occurrence of any serious disturbance of the kind of which I speak.

Before passing on to a new topic I wish to pay a tribute to the men to whom we owe the recent great advances in theoretical dynamical astronomy. As treated by the master-hands of Lagrange and Laplace and their successors, this branch of science hardly seemed to afford scope for any great new departure. But that there is always room for discovery, even in the most frequented paths of knowledge, was illustrated when, nearly thirty years ago, Hill of Washington proposed a new method of treating the theory of the moon's motion in a series of papers which have become classical. I have not time to speak of the enormous labour and great skill involved in the completion of Hill's Lunar Theory, by Ernest Brown, whom I am glad to number amongst my pupils and friends; for I must confine myself to other aspects of Hill's work.

The title of Hill's most fundamental paper, namely, 'On Part of the Motion of the Lunar Perigee,' is almost comic in its modesty, for who would suspect that it contains the essential points involved in the determination of perpetual orbits and their stability? Probably Hill himself did not fully realise at the time the full importance of what he had done. Fortunately he was followed by Poincaré, who not only saw its full meaning but devoted his incomparable mathematical powers to the full theoretical development of the point of view I have been laying before you.

Other mathematicians have also made contributions to this line of investigation, amongst whom I may number my friend Mr. Hough, chief assistant at the Royal Observatory of Cape Town, and myself. But without the work of our two great forerunners we should still be in utter darkness, and it would have been impossible to give even this slight sketch of a great subject.

The theory which I have now explained points to the origin of the sun and planets from gradual accretions of meteoric stones, and it makes no claim to carry the story back behind the time when there was already a central condensation or sun about which there circled another condensation or planet. But more than a century ago an attempt had already been made to reconstruct the history back to a yet remoter past, and, as we shall see, this attempt was based upon quite a different supposition as to the constitution of the primitive solar system. I myself believe that the theory I have just explained, as well as that to which I am coming, contains essential elements of truth, and that the apparent discordances will some day be reconciled. The theory of which I speak

is the celebrated Nebular Hypothesis, first suggested by the German philosopher Kant, and later restated independently and in better form by the French mathematician Laplace.

Laplace traced the origin of the solar system to a nebula or cloud of rarefied gas congregated round a central condensation which was ultimately to form the sun. The whole was slowly rotating about an axis through its centre, and, under the combined influences of rotation and of the mutual attraction of the gas, it assumed a globular form, slightly flattened at the poles. The justifiability of this supposition is confirmed by the observations of astronomers, for they find in the heavens many nebulæ, while the spectroscope proves that their light at any rate is derived from gas. The primeval globular nebula is undoubtedly a stable or persistent figure, and thus Laplace's hypothesis conforms to the general laws which I have attempted to lay down.

The nebula must have gradually cooled by radiation into space, and as it did so the gas must necessarily have lost some of its spring or elasticity. This loss of power of resistance then permitted the gas to crowd more closely towards the central condensation, so that the nebula contracted. The contraction led to two results, both inevitable according to the laws of mechanics: first, the central condensation became hotter; and, secondly, the speed of its rotation became faster. The accelerated rotation led to an increase in the amount of polar flattening, and the nebula at length assumed the form of a lens, or of a disk thicker in the middle than at the edges. Assuming the existence of the primitive nebula, the hypothesis may be accepted thus far as practically certain.

From this point, however, doubt and difficulty enter into the argument. It is supposed that the nebula became so much flattened that it could not subsist as a continuous aggregation of gas, and a ring of matter detached itself from the equatorial regions. The central portions of the nebula, when relieved of the excrescence, resumed the more rounded shape formerly possessed by the whole. As the cooling continued the central portion in its turn became excessively flattened through the influence of its increased rotation; another equatorial ring then detached itself, and the whole process was repeated as before. In this way the whole nebula was fissured into a number of rings surrounding the central condensation, whose temperature must by then have reached incandescence.

Each ring then aggregated itself round some nucleus which happened to exist in its circumference, and so formed a subordinate nebula. Passing through a series of transformations, like its parent, this nebula was finally replaced by a planet with attendant satellites.

The whole process forms a majestic picture of the history of our system. But the mechanical conditions of a rotating nebula are too complex to admit, as yet, of complete mathematical treatment; and thus, in discussing this theory, the physicist is compelled in great measure to adopt the qualitative methods of the biologist, rather than the quantitative ones which he would prefer.

The telescope seems to confirm the general correctness of Laplace's

hypothesis. Thus, for example, the great nebula in Andromeda presents a grand illustration of what we may take to be a planetary system in course of formation. In it we see the central condensation surrounded by a more or less ring-like nebulosity, and in one of the rings there appears to be a subordinate condensation.

Nevertheless it is hardly too much to say that every stage in the supposed process presents to us some difficulty or impossibility. Thus we ask whether a mass of gas of almost inconceivable tenuity can really rotate all in one piece, and whether it is not more probable that there would be a central whirlpool surrounded by more slowly moving parts. Again, is there any sufficient reason to suppose that a series of intermittent efforts would lead to the detachment of distinct rings, and is not a continuous outflow of gas from the equator more probable?

The ring of Saturn seems to have suggested the theory to Laplace; but to take it as a model leads us straight to a quite fundamental difficulty. If a ring of matter ever concentrates under the influence of its mutual attraction, it can only do so round the centre of gravity of the whole ring. Therefore the matter forming an approximately uniform ring, if it concentrates at all, can only fall in on the parent planet and be reabsorbed. Some external force other than the mutual attraction of the matter forming the ring, and therefore not provided by the theory, seems necessary to effect the supposed concentration. The only way of avoiding this difficulty is to suppose the ring to be ill-balanced or lop-sided; in this case, provided the want of balance is pronounced enough, concentration will take place round a point inside the ring but outside the planet. Many writers assume that the present distances of the planets preserve the dimensions of the primitive rings; but the argument that a ring can only aggregate about its centre of gravity, which I do not recollect to have seen before, shows that such cannot be the case.

The concentration of an ill-balanced or broken ring on an interior point would necessarily generate a planet with direct rotation—that is to say, rotating in the same direction as the earth. But several writers, and notably Faye, endeavour to show—erroneously as I think—that a retrograde rotation should be normal, and they are therefore driven to make various complicated suppositions to explain the observed facts. But I do not claim to have removed the difficulty, only to have shifted it; for the satellites of Neptune, and presumably the planet itself, have retrograde rotations; and, lastly, the astonishing discovery has just been made by William Pickering of a ninth retrograde satellite of Saturn, while the rotations of the eight other satellites, of the ring and of the planet itself, are direct. Finally, I express a doubt as to whether the telescope does really exactly confirm the hypothesis of Laplace, for I imagine that what we see indicates a spiral rather than a ring-like division of nebulæ.[1]

[1] Professor Chamberlin, of Chicago, has recently proposed a modified form of the Nebular Hypothesis, in which he contends that the spiral form is normal. See *Year Book*, No. 3, for 1904, of the Carnegie Institution of Washington, pp. 195–258.

This is not the time to pursue these considerations further, but enough has been said to show that the Nebular Hypothesis cannot be considered as a connected intelligible whole, however much of truth it may contain.

In the first theory which I sketched as to the origin of the sun and planets, we supposed them to grow by the accretions of meteoric wanderers in space, and this hypothesis is apparently in fundamental disagreement with the conception of Laplace, who watches the transformations of a continuous gaseous nebula. Some years ago a method occurred to me by which these two discordant schemes of origin might perhaps be reconciled. A gas is not really continuous, but it consists of a vast number of molecules moving in all directions with great speed and frequently coming into collision with one another. Now I have ventured to suggest that a swarm of meteorites would, by frequent collisions, form a medium endowed with so much of the mechanical properties of a gas as would satisfy Laplace's conditions. If this is so, a nebula may be regarded as a quasi-gas, whose molecules are meteorites. The gaseous luminosity which undoubtedly is sent out by nebulæ would then be due only to incandescent gas generated by the clash of meteorites, while the dark bodies themselves would remain invisible. Sir Norman Lockyer finds spectroscopic evidence which led him long ago to some such view as this, and it is certainly of interest to find in his views a possible means of reconciling two apparently totally discordant theories.[1] However, I do not desire to lay much stress on my suggestion, for without doubt a swarm of meteors could only maintain the mechanical properties of a gas for a limited time, and, as pointed out by Professor Chamberlin, it is difficult to understand how a swarm of meteorites moving indiscriminately in every direction could ever have come into existence. But my paper may have served to some extent to suggest to Chamberlin his recent modification of the Nebular Hypothesis, in which he seeks to reconcile Laplace's view with a meteoritic origin of the planetary system.[2]

We have seen that, in order to explain the genesis of planets according to Laplace's theory, the rings must be ill-balanced or even broken. If the ring were so far from being complete as only to cover a small segment of the whole circumference, the true features of the occurrences in the births of planets and satellites might be better represented by conceiving the detached portion of matter to have been more or less globular from the first, rather than ring-shaped. Now this idea introduces us to a group of researches whereby mathematicians have sought to explain the birth of planets and satellites in a way which might appear, at first sight, to be fundamentally different from that of Laplace.

The solution of the problem of evolution involves the search for those persistent or stable forms which biologists would call species. The species of which I am now going to speak may be grouped in a family, which

[1] Newcomb considers the objections to Lockyer's theory insuperable. See p. 190 of *The Stars*, John Murray, London, 1904.

[2] See preceding reference to Chamberlin's Paper.

comprises all those various forms which a mass of rotating liquid is capable of assuming under the conjoint influences of gravitation and rotation. If the earth were formed throughout of a liquid of the same density, it would be one of the species of this family; and indeed these researches date back to the time of Newton, who was the first to explain the figures of planets.

The ideal liquid planets we are to consider must be regarded as working models of actuality, and inasmuch as the liquid is supposed to be incompressible, the conditions depart somewhat widely from those of reality. Hence, when the problem has been solved, much uncertainty remains as to the extent to which our conclusions will be applicable to actual celestial bodies.

We begin, then, with a rotating liquid planet like the earth, which is the first stable species of our family. We next impart in imagination more rotation to this planet, and find by mathematical calculation that its power of resistance to any sort of disturbance is less than it was. In other words, its stability declines with increased rotation, and at length we reach a stage at which the stability just vanishes. At this point the shape is a transitional one, for it is the beginning of a new species with different characteristics from the first, and with a very feeble degree of stability or power of persistence. As a still further amount of rotation is imparted, the stability of the new species increases to a maximum and then declines until a new transitional shape is reached and a new species comes into existence. In this way we pass from species to species with an ever-increasing amount of rotation.

The first or planetary species has a circular equator like the earth; the second species has an oval equator, so that it is something like an egg spinning on its side on a table; in the third species we find that one of the two ends of the egg begins to swell, and that the swelling gradually becomes a well-marked protrusion or filament.[1] Finally the filamentous protrusion becomes bulbous at its end, and is only joined to the main mass of liquid by a gradually thinning neck. The neck at length breaks, and we are left with two separated masses which may be called planet and satellite. It is fair to state that the actual rupture into two bodies is to some extent speculative, since mathematicians have hitherto failed to follow the whole process to the end.[2]

In this ideal problem the successive transmutations of species are brought about by gradual additions to the amount of rotation with which the mass of liquid is endowed. It might seem as if this continuous addition to the amount of rotation were purely arbitrary and could have no counterpart in nature. But real bodies cool and contract in cooling, and,

[1] M. Liapounoff contends that the 'pear-shaped' figure is always unstable ('Sur un problème de Tchebychef,' *Acad. Imp. des Sciences de St-Pétersbourg*, 1905), but I cannot agree with this view—at least for the present.

[2] See a paper by myself on 'Roche's Ellipsoids and on Allied Problems' communicated to the Royal Society, January 1906.

since the scale of magnitude on which our planet is built is immaterial, contraction will produce exactly the same effect on shape as augmented rotation. I must ask you, then, to believe that the effects of an apparently arbitrary increase of rotation may be produced by cooling.

The figures which I succeeded in drawing, by means of rigorous calculation, of the later stages of this course of evolution, are so curious as to remind one of some such phenomenon as the protrusion of a filament of protoplasm from a mass of living matter, and I suggest that we may see in this almost life-like process the counterpart of at least one form of the birth of double stars, planets, and satellites.

As I have already said, Newton determined the first of these figures; Jacobi found the second, and Poincaré indicated the existence of the third, in a paper which is universally regarded as one of the masterpieces of applied mathematics; finally I myself succeeded in determining the exact form of Poincaré's figure, and in proving that it is a true stable shape.

My Cambridge colleague Jeans has also made an interesting contribution to the subject by discussing a closely analogous problem, and he has besides attacked the far more difficult case where the rotating fluid is a compressible gas. In this case also he finds a family of types, but the conception of compressibility introduced a new set of considerations in the transitions from species to species. The problem is, however, of such difficulty that he had to rest content with results which were rather qualitative than strictly quantitative.

This group of investigations brings before us the process of the birth of satellites in a more convincing form than was possible by means of the general considerations adduced by Laplace. It cannot be doubted that the supposed Laplacian sequence of events possesses a considerable element of truth, yet these latter schemes of transformation can be followed in closer detail. It seems, then, probable that both processes furnish us with crude models of reality, and that in some cases the first and in others the second is the better representative.

The moon's mass is one-eightieth of that of the earth, whereas the mass of Titan, the largest satellite in the solar system, is $\frac{1}{4600}$ of that of Saturn. On the ground of this great difference between the relative magnitudes of all other satellites and of the moon, it is not unreasonable to suppose that the mode of separation of the moon from the earth may also have been widely different. The theory of which I shall have next to speak claims to trace the gradual departure of the moon from an original position not far removed from the present surface of the earth. If this view is correct, we may suppose that the detachment of the moon from the earth occurred as a single portion of matter, and not as a concentration of a Laplacian ring.

If a planet is covered with oceans of water and air, or if it is formed of plastic molten rock, tidal oscillations must be generated in its mobile parts by the attractions of its satellites and of the sun. Such movements must be subject to frictional resistance, and the planet's rotation will be

slowly retarded by tidal friction in much the same way that a fly-wheel is gradually stopped by any external cause of friction. Since action and reaction are equal and opposite, the action of the satellites on the planet, which causes the tidal friction of which I speak, must correspond to a reaction of the planet on the motion of the satellites.

At any moment of time we may regard the system composed of the rotating planet with its attendant satellite as a stable species of motion, but the friction of the tides introduces forces which produce a continuous, although slow, transformation in the configuration. It is, then, clearly of interest to trace backwards in time the changes produced by such a continuously acting cause, and to determine the initial condition from which the system of planet and satellite must have been slowly degrading. We may also look forward, and discover whither the transformation tends.

Let us consider, then, the motion of the earth and moon revolving in company round the sun, on the supposition that the friction of the tides in the earth is the only effective cause of change. We are, in fact, to discuss a working model of the system, analogous to those of which I have so often spoken before.

This is not the time to attempt a complete exposition of the manner in which tidal friction gives rise to the action and reaction between planet and satellite, nor shall I discuss in detail the effects of various kinds which are produced by this cause. It must suffice to set forth the results in their main outlines, and, as in connection with the topic of evolution retrospect is perhaps of greater interest than prophecy, I shall begin with the consideration of the past.

At the present time the moon, moving at a distance of 240,000 miles from the earth, completes her circuit in twenty-seven days. Since a day is the time of one rotation of the earth on its axis, the angular motion of the earth is twenty-seven times as rapid as that of the moon.

Tidal friction acts as a brake on the earth, and therefore we look back in retrospect to times when the day was successively twenty-three, twenty-two, twenty-one of our present hours in length, and so on backward to still shorter days. But during all this time the reaction on the moon was at work, and it appears that its effect must have been such that the moon also revolved round the earth in a shorter period than it does now; thus the month also was shorter in absolute time than it now is. These conclusions are absolutely certain, although the effects on the motions of the earth and of the moon are so gradual that they can only doubtfully be detected by the most refined astronomical measurements.

We take the 'day,' regarding it as a period of variable length, to mean the time occupied by a single rotation of the earth on its axis; and the 'month,' likewise variable in absolute length, to mean the time occupied by the moon in a single revolution round the earth. Then, although there are now twenty-seven days in a month, and although both day and month were shorter in the past, yet there is, so far, nothing to tell us whether there were more or less days in the month in the past. For if

the day is now being prolonged more rapidly than the month, the number of days in the month was greater in the past than it now is; and if the converse were true, the number of days in the month was less.

Now it appears from mathematical calculation that the day must now be suffering a greater degree of prolongation than the month, and accordingly in retrospect we look back to a time when there were more days in the month than at present. That number was once twenty-nine, in place of the present twenty-seven; but the epoch of twenty-nine days in the month is a sort of crisis in the history of moon and earth, for yet earlier the day was shortening less rapidly than the month. Hence, earlier than the time when there were twenty-nine days in the month, there was a time when there was a reversion to the present smaller number of days.

We thus arrive at the curious conclusion that there is a certain number of days to the month, namely twenty-nine, which can never have been exceeded, and we find that this crisis was passed through by the earth and moon recently; but, of course, a recent event in such a long history may be one which happened some millions of years ago.

Continuing our retrospect beyond this crisis, both day and month are found continuously shortening, and the number of days in the month continues to fall. No change in conditions which we need pause to consider now supervenes, and we may ask at once, what is the initial stage to which the gradual transformation points? I say, then, that on following the argument to its end the system may be traced back to a time when the day and month were identical in length, and were both only about four or five of our present hours. The identity of day and month means that the moon was always opposite to the same side of the earth; thus at the beginning the earth always presented the same face to the moon, just as the moon now always shows the same face to us. Moreover, when the month was only some four or five of our present hours in length the moon must have been only a few thousand miles from the earth's surface—a great contrast with the present distance of 240,000 miles.

It might well be argued from this conclusion alone that the moon separated from the earth more or less as a single portion of matter at a time immediately antecedent to the initial stage to which she has been traced. But there exists a yet more weighty argument favourable to this view, for it appears that the initial stage is one in which the stability of the species of motion is tottering, so that the system presents the characteristic of a transitional form, which we have seen to denote a change of type or species in a previous case.

In discussing the transformations of a liquid planet we saw the tendency of the single mass to divide into two portions, although we failed to extend the rigorous argument back to the actual moment of separation; and now we seem to reach a similar crisis from the opposite end, when in retrospect we trace back the system to two masses of unequal size in close proximity with one another. The argument almost

carries conviction with it, but I have necessarily been compelled to pass over various doubtful points.

Time is wanting to consider other subjects worthy of notice which arise out of this problem, yet I wish to point out that the earth's axis must once have been less tilted over with reference to the sun than it is now, so that the obliquity of the ecliptic receives at least a partial explanation. Again, the inclination of the moon's orbit may be in great measure explained; and, lastly, the moon must once have moved in a nearly circular path. The fact that tidal friction is competent to explain the eccentricity of an orbit has been applied in a manner to which I shall have occasion to return hereafter.

In my paper on this subject I summed up the discussion in the following words, which I still see no reason to retract:—

'The argument reposes on the imperfect rigidity of solids, and on the internal friction of semi-solids and fluids; these are *veræ causæ*. Thus changes of the kind here discussed must be going on, and must have gone on in the past. And for this history of the earth and moon to be true throughout it is only necessary to postulate a sufficient lapse of time, and that there is not enough matter diffused through space materially to resist the motions of the moon and earth in perhaps several hundred million years.

'It hardly seems too much to say that granting these two postulates and the existence of a primeval planet, such as that above described, then a system would necessarily be developed which would bear a strong resemblance to our own.

'A theory, reposing on *veræ causæ*, which brings into quantitative correlation the lengths of the present day and month, the obliquity of the ecliptic, and the inclination and eccentricity of the lunar orbit, must, I think, have strong claims to acceptance.' [1]

We have pursued the changes into the past, and I will refer but shortly to the future. The day and month are both now lengthening, but the day changes more quickly than the month. Thus the two periods tend again to become equal to one another, and it appears that when that goal is reached both day and month will be as long as fifty-five of our present days. The earth will then always show the same face to the moon, just as it did in the remotest past. But there is a great contrast between the ultimate and initial conditions, for the ultimate stage, with day and month both equal to fifty-five of our present days, is one of great stability in contradistinction to the vanishing stability which we found in the initial stage.

Since the relationship between the moon and earth is a mutual one, the earth may be regarded as a satellite of the moon, and if the moon rotated rapidly on her axis, as was probably once the case, the earth must at that time have produced tides in the moon. The mass of the moon is relatively small, and the tides produced by the earth would be

[1] *Phil. Trans.*, pt. ii., 1880, p. 883.

large; accordingly the moon would pass through the several stages of her history much more rapidly than the earth. Hence it is that the moon has already advanced to that condition which we foresee as the future fate of the earth, and now always shows to us the same face.

If the earth and moon were the only bodies in existence, this ultimate stage, when the day and month were again identical in length, would be one of absolute stability, and therefore eternal; but the presence of the sun introduces a cause for yet further changes. I do not, however, propose to pursue the history to this yet remoter futurity, because our system must contain other seeds of decay which will probably bear fruit before these further transformations could take effect.

If, as has been argued, tidal friction has played so important a part in the history of the earth and moon, it might be expected that the like should be true of the other planets and satellites, and of the planets themselves in their relationship to the sun. But numerical examination of the several cases proves conclusively that this cannot have been the case. The relationship of the moon to the earth is in fact quite exceptional in the solar system, and we have still to rely on such theories as that of Laplace for the explanation of the main outlines of the solar system.

I have as yet only barely mentioned the time occupied by the sequence of events sketched out in the various schemes of cosmogony, and the question of cosmical time is a thorny and controversial one.

Our ideas are absolutely blank as to the time requisite for the evolution according to Laplace's nebular hypothesis. And again, if we adopt the meteoritic theory, no estimate can be formed of the time required even for an ideal sun, with its attendant planet Jove, to sweep up the wanderers in space. We do know, indeed, that there is a continuous gradation from stable to unstable orbits, so that some meteoric stones may make thousands or millions of revolutions before meeting their fate by collision. Accordingly, not only would a complete absorption of all the wanderers occupy an infinite time, but also the amount of the refuse of the solar system still remaining scattered in planetary space is unknown. And, indeed, it is certain that the process of clearance is still going on, for the earth is constantly meeting meteoric stones, which, penetrating the atmosphere, become luminous through the effects of the frictional resistance with which they meet.

All we can assert of such theories is that they demand enormous intervals of time as estimated in years.

The theory of tidal friction stands alone amongst these evolutionary speculations in that we can establish an exact but merely relative time-scale for every stage of the process. It is true that the value in years of the unit of time remains unknown, and it may be conjectured that the unit has varied to some extent as the physical condition of the earth has gradually changed.

It is, however, possible to determine a period in years which must be shorter than that in which the whole history is comprised. If at every

moment since the birth of the moon tidal friction had always been at work in such a way as to produce the greatest possible effect, then we should find that sixty million years would be consumed in this portion of evolutionary history. The true period must be much greater, and it does not seem extravagant to suppose that 500 to 1,000 million years may have elapsed since the birth of the moon.

Such an estimate would not seem extravagant to geologists who have, in various ways, made exceedingly rough determinations of geological periods. One such determination is derived from measures of the thickness of deposited strata, and the rate of the denudation of continents by rain and rivers. I will not attempt to make any precise statement on this head, but I imagine that the sort of unit with which the geologist deals is 100 million years, and that he would not consider any estimate involving from one to twenty of such units as unreasonable.

Mellard Reade has attempted to determine geological time by certain arguments as to the rate of denudation of limestone rocks, and arrives at the conclusion that geological history is comprised in something less than 600 million years.[1] The uncertainty of this estimate is wide, and I imagine that geologists in general would not lay much stress on it.

Joly has employed a somewhat similar, but probably less risky, method of determination.[2] When the earth was still hot, all the water of the globe must have existed in the form of steam, and when the surface cooled that steam must have condensed as fresh water. Rain then washed the continents and carried down detritus and soluble matter to the seas. Common salt is the most widely diffused of all such soluble matter, and its transit to the sea is an irreversible process, because the evaporation of the sea only carries back to the land fresh water in the form of rain. It seems certain, then, that the saltness of the sea is due to the washing of the land throughout geological time.

Rough estimates may be formed of the amount of river water which reaches the sea in a year, and the measured saltness of rivers furnishes a knowledge of the amount of salt which is thus carried to the sea. A closer estimate may be formed of the total amount of salt in the sea. On dividing the total amount of salt by the annual transport Joly arrives at the quotient of about 100 millions, and thence concludes that geological history has occupied 100 million years. I will not pause to consider the several doubts and difficulties which arise in the working out of this theory. The uncertainties involved must clearly be considerable, yet it seems the best of all the purely geological arguments whence we derive numerical estimates of geological time. On the whole I should say that pure geology points to some period intermediate between 50 and 1,000 millions of years, but the upper limit is more doubtful than the lower.

[1] *Chemical Denudation in relation to Geological Time*, Bogue, London, 1879; or *Roy. Soc.* January 23, 1879.

[2] 'An Estimate of the Geological Age of the Earth,' *Trans. Roy. Dublin Soc.*, vol. vii. series iii., 1902, pp. 23–66.

Thus far we do not find anything which renders the tidal theory of evolution untenable.

But the physicists have formed estimates in other ways which, until recently, seemed to demand in the most imperative manner a far lower scale of time. According to all theories of cosmogony, the sun is a star which became heated in the process of its condensation from a condition of wide dispersion. When a meteoric stone falls into the sun the arrest of its previous motion gives rise to heat, just as the blow of a horse's shoe on a stone makes a spark. The fall of countless meteoric stones, or the condensation of a rarefied gas, was supposed to be the sole cause of the sun's high temperature.

Since the mass of the sun is known, the total amount of the heat generated in it, in whatever mode it was formed, can be estimated with a considerable amount of precision. The heat received at the earth from the sun can also be measured with some accuracy, and hence it is a mere matter of calculation to determine how much heat the sun sends out in a year. The total heat which can have been generated in the sun divided by the annual output gives a quotient of about 20 millions. Hence it seemed to be imperatively necessary that the whole history of the solar system should be comprised within some 20 millions of years.

This argument, which is due to Helmholtz, appeared to be absolutely crushing, and for the last forty years the physicists have been accustomed to tell the geologists that they must moderate their claims. But for myself I have always believed that the geologists were more nearly correct than the physicists, notwithstanding the fact that appearances were so strongly against them.

And now, at length, relief has come to the strained relations between the two parties, for the recent marvellous discoveries in physics show that concentration of matter is not the only source from which the sun may draw its heat.

Radium is a substance which is perhaps millions of times more powerful than dynamite. Thus it is estimated that an ounce of radium would contain enough power to raise 10,000 tons a mile above the earth's surface. Another way of stating the same estimate is this : the energy needed to tow a ship of 12,000 tons a distance of six thousand sea miles at 15 knots is contained in 22 ounces of radium. The 'Saxon' probably burns three or four thousand tons of coal on a voyage of approximately the same length. Again, M. and Mme. Curie have proved that radium actually gives out heat,[1] and it has been calculated that a small proportion of radium in the sun would suffice to explain its present radiation. Other lines of argument tend in the same direction.[2]

[1] Lord Kelvin has estimated the age of the earth from the rate of increase of temperature underground. But the force of his argument seems to be entirely destroyed by this result. See a letter by R. J. Strutt, *Nature*, December 21, 1905.

[2] See W. E. Wilson, *Nature*, July 9, 1903; and G. H. Darwin, *Nature*, September 24, 1903.

Now we know that the earth contains radio-active materials, and it is safe to assume that it forms in some degree a sample of the materials of the solar system. Hence it is almost certain that the sun is radio-active also; and besides it is not improbable that an element with so heavy an atom as radium would gravitate more abundantly to the central condensation than to the outlying planets. In this case the sun should contain a larger proportion of radio-active material than the earth.

This branch of science is as yet but in its infancy, but we already see how unsafe it is to dogmatise on the potentialities of matter.

It appears, then, that the physical argument is not susceptible of a greater degree of certainty than that of the geologists, and the scale of geological time remains in great measure unknown.

I have now ended my discussion of the solar system, and must pass on to the wider fields of the stellar universe.

Only a few thousand stars are visible with the unaided eye, but photography has revealed an inconceivably vast multitude of stars and nebulæ, and every improvement in that art seems to disclose yet more and more. About twenty years ago the number of photographic objects in the heavens was roughly estimated at about 170 millions, and some ten years later it had increased to about 400 millions. Although Newcomb, in his recent book on 'The Stars,' refrains even from conjecturing any definite number, yet I suppose that the enormous number of 400 millions must now be far below the mark, and photography still grows better year by year. It seems useless to consider whether the number of stars has any limit, for infinite number, space, and time transcend our powers of comprehension. We must then make a virtue of necessity, and confine our attention to such more limited views as seem within our powers.

A celestial photograph looks at first like a dark sheet of paper splashed with whitewash, but further examination shows that there is some degree of method in the arrangement of the white spots. It may be observed that the stars in many places are arranged in lines and sweeping trains, and chains of stars, arranged in roughly parallel curves, seem to be drawn round some centre. A surface splashed at hazard might present apparent evidence of system in a few instances, but the frequency of the occurrence in the heavens renders the hypothesis of mere chance altogether incredible.

Thus there is order of some sort in the heavens, and, although no reason can be assigned for the observed arrangement in any particular case, yet it is possible to obtain general ideas as to the succession of events in stellar evolution.

Besides the stars there are numerous streaks, wisps, and agglomerations of nebulosity, whose light we know to emanate from gas. Spots of intenser light are observed in less brilliant regions; clusters of stars are sometimes imbedded in nebulosity, while in other cases each individual

star of a cluster stands out clear by itself. These and other observations force on us the conviction that the wispy clouds represent the earliest stage of development, the more condensed nebulæ a later stage, and the stars themselves the last stage. This view is in agreement with the nebular hypothesis of Laplace, and we may fairly conjecture that the chains and lines of stars represent pre-existing streaks of nebulosity.

As a star cools it must change, and the changes which it undergoes constitute its life-history, hence the history of a star presents an analogy with the life of an individual animal. Now, the object which I have had in view has been to trace types or species in the physical world through their transformations into other types. Accordingly it falls somewhat outside the scope of this address to consider the constitution and history of an individual star, interesting although those questions are. I may, however, mention that the constitution of gaseous stars was first discussed from the theoretical side by Lane, and subsequently more completely by Ritter. On the observational side the spectroscope has proved to be a powerful instrument in analysing the constitutions of the stars, and in assigning to them their respective stages of development.

If we are correct in believing that stars are condensations of matter originally more widely spread, a certain space surrounding each star must have been cleared of nebulosity in the course of its formation. Much thought has been devoted to the determination of the distribution of the stars in space, and although the results are lacking in precision, yet it has been found possible to arrive at a rough determination of the average distance from star to star. It has been concluded, from investigations into which I cannot enter, that if we draw a sphere round the sun with a radius of twenty million millions of miles,[1] it will contain no other star; if the radius were twice as great the sphere might perhaps contain one other star; a sphere with a radius of sixty million millions of miles will contain about four stars. This serves to give some idea of the extraordinary sparseness of the average stellar population; but there are probably in the heavens urban and rural districts, as on earth, where the stars may be either more or less crowded. The stars are moving relatively to one another with speeds which are enormous, as estimated by terrestrial standards, but the distances which separate us from them are so immense that it needs refined observation to detect and measure the movements.

Change is obviously in progress everywhere, as well in each individual nebula and star as in the positions of these bodies relatively to one another. But we are unable even to form conjectures as to the tendency of the evolution which is going on. This being so, we cannot expect, by considering the distribution of stars and nebulæ, to find many illustrations of the general laws of evolution which I have attempted to explain; accordingly I must confine myself to the few cases where we at least fancy our-

[1] This is the distance at which the earth's distance from the sun would appear to be 1″.

selves able to form ideas as to the stages by which the present conditions have been reached.

Up to a few years ago there was no evidence that the law of gravitation extended to the stars, and even now there is nothing to prove the transmission of gravity from star to star. But in the neighbourhood of many stars the existence of gravity is now as clearly demonstrated as within the solar system itself. The telescope has disclosed the double character of a large number of stars, and the relative motions of the pairs of companions have been observed with the same assiduity as that of the planets. When the relative orbit of a pair of binary or double stars is examined, it is found that the motion conforms exactly to those laws of Kepler which prove that the planets circle round the sun under the action of solar gravitation. The success of the hypothesis of stellar gravitation has been so complete that astronomers have not hesitated to explain the anomalous motion of a seemingly single star by the existence of a dark companion ; and it is interesting to know that the more powerful telescopes of recent times have disclosed, in at least two cases, a faintly luminous companion in the position which had been assigned to it by theory.

By an extension of the same argument, certain variations in the spectra of a considerable number of stars have been pronounced to prove them each to be really double, although in general the pair may be so distant that they will probably always remain single to our sight. Lastly, the variability in the light of other apparently single stars has proved them to be really double. A pair of stars may partially or wholly cover one another as they revolve in their orbit, and the light of the seemingly single star will then be eclipsed, just as a lighthouse winks when the light is periodically hidden by a revolving shutter. Exact measurements of the character of the variability in the light have rendered it possible not only to determine the nature of the orbit described, but even to discover the figures and densities of the two components which are fused together by the enormous distance of our point of view. This is a branch of astronomy to which much careful observation and skilful analysis has been devoted ; and I am glad to mention that Alexander Roberts, one of the most eminent of the astronomers who have considered the nature of variable stars, is a resident in South Africa.

I must not, however, allow you to suppose that the theory of eclipses will serve to explain the variability of all stars, for there are undoubtedly others whose periodicity must be explained by something in their internal constitution.

The periods of double stars are extremely various, and naturally those of short period have been the first noted ; in times to come others with longer and longer periods will certainly be discovered. A leading characteristic of all these double stars is that the two companions do not differ enormously in mass from one another. In this respect these systems present a strongly marked contrast with that of the sun, attended as it is by relatively insignificant planets.

In the earlier part of my address I showed how theory indicates that a rotating fluid body will as it cools separate into two detached masses. Mathematicians have not yet been able to carry their analysis far enough to determine the relative magnitudes of the two parts, but as far as we can see the results point to the birth of a satellite whose mass is a considerable fraction of that of its parent. Accordingly See (who devotes his attention largely to the astronomy of double stars), Roberts, and others consider that what they have observed in the heavens is in agreement with the indications of theory. It thus appears that there is reason to hold that double stars have been generated by the division of primitive and more diffused single stars.

But if this theory is correct we should expect the orbit of a double star to be approximately circular; yet this is so far from being the case that the eccentricity of the orbits of many double stars exceeds by far any of the eccentricities in the solar system. Now See has pointed out that when two bodies of not very unequal masses revolve round one another in close proximity the conditions are such as to make tidal friction as efficient as possible in transforming the orbit. Hence we seem to see in tidal friction a cause which may have sufficed not only to separate the two component stars from one another, but also to render the orbit eccentric.

I have thought it best to deal very briefly with stellar astronomy, in spite of the importance of the subject, because the direction of the changes in progress is in general too vague to admit of the formation of profitable theories.

We have seen that it is possible to trace the solar system back to a primitive nebula with some degree of confidence, and that there is reason to believe that the stars in general have originated in the same manner. But such primitive nebulæ stand in as much need of explanation as their stellar offspring. Thus, even if we grant the exact truth of these theories, the advance towards an explanation of the universe remains miserably slight. Man is but a microscopic being relatively to astronomical space, and he lives on a puny planet circling round a star of inferior rank. Does it not then seem as futile to imagine that he can discover the origin and tendency of the universe as to expect a housefly to instruct us as to the theory of the motions of the planets? And yet, so long as he shall last, he will pursue his search, and will no doubt discover many wonderful things which are still hidden. We may indeed be amazed at all that man has been able to find out, but the immeasurable magnitude of the undiscovered will throughout all time remain to humble his pride. Our children's children will still be gazing and marvelling at the starry heavens, but the riddle will never be read.

REPORTS

ON THE

STATE OF SCIENCE.

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Corresponding Societies Committee.—Report of the Committee, consisting of Mr. W. WHITAKER (*Chairman*), Mr. F. W. RUDLER (*Secretary*), Rev. J. O. BEVAN, Dr. HORACE T. BROWN, Dr. VAUGHAN CORNISH, Principal E. H. GRIFFITHS, Mr. T. V. HOLMES, Mr. J. HOPKINSON, Professor R. MELDOLA, Dr. H. R. MILL, Mr. C. H. READ, Rev. T. R. R. STEBBING, Professor W. W. WATTS, *and the* GENERAL OFFICERS. (*Drawn up by the Secretary.*)

THE Committee beg leave to report that at several meetings during the past session they have had under consideration the suggestions with reference to Corresponding Societies which were brought forward by Principal E. H. Griffiths at the Conference of Delegates at Cambridge last year. In accordance with a Resolution passed at that meeting, and sent up to the Committee of Recommendations, the General Committee of the Association appointed a Committee, consisting of certain Members of the Council, with representatives of the Corresponding Societies, in order to consider the present relation between the British Association and the local scientific societies, with power to make suggestions for the greater utilisation of such relationship. This Joint Committee duly reported to the Council of the Association, and their Report was remitted by the Council to the Corresponding Societies Committee. The recommendations in the Report were discussed and amended by this Committee, and were finally adopted, in the amended form, by the Council.

As a result of this discussion there will henceforth be two classes of local societies eligible for relationship with the British Association. One class, to be called *Affiliated Societies*, will consist, as at present, of such societies as undertake local scientific investigation and publish the results. Each Affiliated Society may be represented at the meetings of the British Association by a delegate, who must be a Member of the Association, and who will be, for the time being, a member of the General Committee. The new class of corresponding societies, to be called *Associated Societies*, will include societies formed for the purpose of encouraging the study of science, which have been in existence for at least three years and number not fewer than fifty members. Each Associated Society will have the right to appoint a delegate to attend the Annual Conference. This delegate, who may be either a Member or

an Associate of the British Association, will have all the rights of a delegate from an Affiliated Society, except that of membership of the General Committee.

With regard to the suggestion made in the Chairman's Address to the Delegates at Cambridge, that a 'Journal of Corresponding Societies' should be established, the Committee, after very careful consideration of the subject, came unanimously, though regretfully, to the conclusion that, in their opinion, the publication of such a Journal by the British Association would be impracticable.

The question of obtaining, if possible, reduced railway rates for members of local scientific societies when travelling even singly for scientific purposes was referred to this Committee by the Delegates at the Cambridge Conference. A form of application to the various railway companies has consequently been drafted, and distributed to all the Affiliated Societies with the view of ascertaining their opinion. This application has been generally, but not unanimously, approved, and it now remains for the Committee to submit the matter to the Council of the Association before further action can be taken.

In view of the visit of the British Association to South Africa, it has been felt that the most convenient course to adopt this year would be to hold the Conference of Delegates in London after the South African meeting. This suggestion has been approved by the Council, and it has consequently been arranged that the Conference shall be held on October 30 and 31, the latter being the date of a meeting in London of the General Committee of the British Association, which the delegates of the Affiliated Societies have a right to attend.

It is proposed that at this Conference the following subjects, among others, shall be discussed :—

1. The Preservation of our Native Plants.
2. The Law of Treasure Trove.
3. Copyright Law as it affects Scientific Societies.

The usual Schedule of Questions has been sent out to the Affiliated Societies, and from the returns which have been received it appears that twenty-one Societies have been engaged during the past session in more or less original scientific work of a local character.

The City of London College Science Society has been added to the list of Corresponding Societies.

As the Isle of Man Natural History and Antiquarian Society has failed to return the Schedule after repeated application, the Committee regret that they are compelled to recommend its removal from the list of Corresponding Societies.

The Committee ask to be reappointed with a grant of 25*l.* As the Committee have been charged by the Council with the duty of collecting information regarding the Societies of the United Kingdom which are eligible for relation with the British Association under the new class of Associated Societies, much additional correspondence, needing extra expenditure for clerical assistance, &c., will be thrown upon the Committee during the forthcoming year. It will probably not be easy to discover all the smaller societies scattered throughout the country, and the Committee will consequently be glad of any information which will assist them in this branch of their work.

Report of the Conference of Delegates of Corresponding Societies held in the Rooms of the Linnean Society, Burlington House, London, October 30 *and* 31, 1905.

Chairman . .	A. Smith Woodward, LL.D., F.R.S.
Vice-Chairman .	W. Whitaker, B.A., F.R.S.
Secretary . .	F. W. Rudler, I.S.O.

The following Corresponding Societies nominated Delegates to represent them at the Conference. The attendance of the Delegates is indicated in the list by the figures 1 and 2 placed in the margin opposite to the name of each Society, and referring respectively to the first and second meetings. Where no figure is shown it will be understood that the Delegate did not attend.[1]

List of Societies sending Delegates.

		Andersonian Naturalists' Society .	M. A. B. Gilmour, F.Z.S.
1	2	Bath Natural History and Antiquarian Field Club.	Rev. C. W. Shickle, M.A., F.S.A.
1	2	Belfast Naturalists' Field Club . .	W. Gray, M.R.I.A.
		Belfast Natural History and Philosophical Society.	Dr. Johnson Symington, F.R.S.
		Berwickshire Naturalists' Club . .	A. H. Evans, M.A., F.Z.S.
		Birmingham and Midland Institute Scientific Society.	W. Bayley Marshall, M.Inst.C.E.
		Birmingham Natural History and Philosophical Society.	C. J. Watson.
		Buchan Field Club	J. F. Tocher, F.I.C.
		Caradoc and Severn Valley Field Club	Professor W. W. Watts, F.R.S.
		Cardiff Naturalists' Society . .	Principal E. H. Griffiths, D.Sc., F.R.S.
		Croydon Natural History and Scientific Society.	W. F. Stanley, F.G.S.
1	2	Dorset Natural History and Antiquarian Field Club.	E. R. Sykes, B.A.
		Dublin Naturalists' Field Club . .	Prof. G. A. J. Cole, F.G.S.
		East Kent Scientific and Natural History Society.	A. S. Reid, M.A.
1	2	Elgin and Morayshire Literary and Scientific Association.	W. Taylor, J.P.
1	2	Essex Field Club	F. W. Rudler, I.S.O.
		Glasgow Geological Society . .	J. B. Murdoch.
1	2	Glasgow Natural History Society .	Peter Ewing, F.L.S.
		Glasgow Royal Philosophical Society	G. T. Beilby.
		Halifax Scientific Society . . .	W. Simpson, F.G.S.
1		Hampshire Field Club and Archæological Society.	W. Dale, F.S.A.
	2	Haslemere Microscope and Natural History Society.	Hon. Rollo Russell.
	2	Hertfordshire Natural History Society	J. Hopkinson, F.L.S.
1	2	Holmesdale Natural History Club .	Rev. R. Ashington Bullen, B.A., F.L.S.
	2	Hull Geological Society	G. W. B. Macturk.
1		Hull Scientific and Field Naturalists' Club.	T. Sheppard, F.G.S.
1	2	Institution of Mining Engineers .	J. A. Longden, M.Inst.C.E.
		Leeds Geological Association . .	Professor P. F. Kendall, F.G.S.
1	2	Leeds Naturalists' Club and Scientific Association.	H. C. Marsh.

[1] The attendances are taken from the Attendance-book, which each Delegate is requested to sign on entering the Meeting-room.

		Society	Delegate
		Liverpool Geographical Society	James Irvine, F.R.G.S.
		Liverpool Geological Society	Joseph Lomas, F.G.S.
1	2	London: City of London College Science Society	J. Logan Lobley, F.G.S.
1	2	Manchester Geographical Society	J. Howard Reed.
1	2	Manchester Geological and Mining Society.	William Watts.
1	2	Manchester Microscopical Society	F. W. Hembry, F.R.M.S.
1	2	Midland Counties Institution of Engineers.	J. A. Longden, M.Inst.C.E.
		Midland Institute of Mining, Civil, and Mechanical Engineers.	Arnold Lupton, M.Inst.C.E.
1	2	Norfolk and Norwich Naturalists' Society.	Eustace Gurney.
1	2	Northamptonshire Natural History Society and Field Club.	Beeby Thompson, F.G.S.
		North of England Institute of Mining and Mechanical Engineers.	A. R. Sawyer.
	2	North Staffordshire Field Club	W. D. Spanton, F.R.C.S.
		Northumberland, Durham, and Newcastle-upon-Tyne Natural History Society.	N. H Martin, F.R.S.E.
		Nottingham Naturalists' Society	Prof. J. W. Carr, M.A., F.L.S.
1	2	Paisley Philosophical Institution	Wm. Peattie.
1	2	Perthshire Society of Natural Science	H. Coates, F.R.S.E.
1	2	Quekett Microscopical Club	C. F. Rousselet, F.R.M.S.
1	2	Rochdale Literary and Scientific Society.	J. R. Ashworth, D.Sc.
	2	Somersetshire Archæological and Natural History Society.	F. J. Clark, F.L.S.
1	2	South-Eastern Union of Scientific Societies.	Rev. R. Ashington Bullen, B.A., F.L.S.
		South Staffordshire and East Worcestershire Institute of Mining Engineers.	A. R. Sawyer.
		Tyneside Geographical Society	Herbert Shaw, F.R.G.S.
1	2	Woolhope Naturalists' Field Club	Rev. J. O. Bevan, M.A., F.S.A.
1	2	Yorkshire Geological and Polytechnic Society.	Rev. W. Lower Carter, M.A.
1		Yorkshire Naturalists' Union	T. Sheppard, F.G.S.
	2	Yorkshire Philosophical Society	Dr. Tempest Anderson.

First Meeting, October 30.

This Meeting was presided over by Dr. Smith Woodward, F.R.S. The Corresponding Societies Committee were represented by Mr. Whitaker, F.R.S., the Rev. J. O. Bevan, the Rev. T. R. R. Stebbing, F.R.S., Dr. J. G. Garson, Dr. H. R. Mill, Mr. J. Hopkinson, and Mr. Rudler.

The Chairman of the Conference, after welcoming the Delegates, delivered the following Address :—

Chairman's Address.

I esteem it a special honour to have been deputed by the Council to preside over this Conference of Delegates, because there is no nation in the world in which local Scientific Societies are so numerous or form so prominent a feature of intellectual life as in the kingdom of Great Britain and Ireland. I also undertake the duty with peculiar pleasure, because I began my scientific career as an active member of the small Society at one time flourishing in my native town, and it was then that I first learned how to observe and how to write down my observations in a

logical form. None but those who have associated with the scientific men of other countries, and have seen the splendid isolation in which most of them are accustomed to work, can appreciate the service which our scattered small Societies render to the cause of natural science here. Through the influence of these bodies everyone who is able to devote his energies to original research is assured the sympathy, and frequently the help, of a multitude of cultured men who are too much occupied with other pursuits to give more than superficial attention to natural science. Through the same influence also a continual stream of recruits is furnished to the great Societies in our three metropolitan centres, whose activities and resources excite the admiration, if not the envy, of our colleagues in scientific research abroad.

The purpose of this Conference, however, is not to dilate on our happy circumstances and achievements, but rather to consider how we can render the organisation and work of the Societies more effective in promoting the objects for which the British Association exists. I therefore hope I may be pardoned if I devote the greater part of my brief Address to critical remarks and suggestions. One who comes into contact with many local Societies, and takes little part in the work of any, receives impressions which may interest those among the Delegates who have not had the opportunity of taking the same broad point of view. Some of these impressions I purpose to recount.

In the first place it seems to me that some of the Societies—especially the Field Clubs, which admit too many so-called 'antiquarians'—continually reduce their efficiency, and even endanger their existence as scientific bodies, by the luxurious picnics which are misnamed 'excursions.' The excursion-circulars of one Society, which I often see, particularly amuse me. The hour of starting is made sufficiently late to avoid the discomforts of even moderately early rising; carriages are arranged for every possible part of the route; at least an hour is spent in an elaborate luncheon at some well-appointed hostelry; an hour and a half afterwards an amiable hostess invites the party to tea; and then, after inspecting some old building, the direct return journey is begun. Natural history forms an entirely subordinate part of the programme. I know three Societies which have lost the co-operation of some of the best naturalists in their district by frivolity of this kind; and, however tempting the prospect of multiplied subscriptions may be, I do not think it is to the advantage of science for any Society to increase its membership at the sacrifice of strict attention to its main objects. Excursions are a most admirable institution, but when intended for the study of natural history should be as systematically scientific as the meetings.

Again, I would allude for a moment to the intellectual entertainment provided at the evening meetings. As remarked by my predecessor last year, there can be no doubt that the best work done by the smaller Societies is that of instruction in the current progress of science, and the presentation of the matter in such a form as to rouse interest in scientific pursuits. In most cases this work is admirably done by the various members who happen to be absorbed in the different branches of science to which they devote their leisure; but some Societies are more ambitious and, while maintaining their original very moderate subscription, exert all the personal influence they can command to induce professional scientific men to come and give them, as an entirely gratuitous service, the fruit of their life-long studies. I know one Society, consisting mainly

of well-to-do people, which has already carried on this practice for several years. By personal solicitation, which it is difficult to refuse, they induce professional men not only to lecture, but to take the trouble to make their lectures popularly entertaining; and yet the members pay less for the whole season's course than most of them would have neither hesitation nor difficulty in paying for a single seat at a concert. Now professional scientific men, as a rule, are so much interested in their researches that they are only too ready to communicate whatever they can to any sympathetic inquirer; but it rarely happens that their ordinary income is commensurate with the circumstances in which they are compelled to live. It is therefore unfair, to say the least, to expect them to do real hard work, such as a popular lecture entails, without being provided with the fee which would go as a matter of course to the medical man, lawyer, or musician in the exercise of any of his professional duties. If a Society decides to arrange for the highest type of instruction, it should in any case make the subscription sufficiently large to prevent this teaching from being done at the expense of those who can least afford it.

Even in the case of Societies whose main object is to encourage original research, it is becoming more and more expedient to restrict the meetings almost entirely to general discourses and demonstrations. Nearly all original papers are now of necessity so technical that they must be studied closely in print before they can be appreciated; and the most active even of the metropolitan Societies are those which make a special feature of 'exhibits' while taking the majority of papers as 'read.' I have often thought that in the smaller local Societies much might be accomplished by making special arrangements for papers by real workers to treat of the unsolved problems of the sciences in which they are interested. I believe it is a maxim among ordinary teachers that the learner must be told facts as definitely as possible, and not allowed to suspect that there may be doubt about any of them. Consequently all elementary books of instruction are written to give the impression that there is no particular in which the knowledge they contain can be improved. For the guidance of more advanced students, who know better, we are distinctly in need of a series of books to treat of ignorance rather than knowledge; and until these are forthcoming the Societies cannot do more important service to research than that of supplying the deficiency.

The allusion to books of reference reminds me of another direction in which the local Societies might with advantage exert more influence than they are commonly accustomed to do. The selection of books on natural science in many of our smaller public libraries can only be described as lamentable. Not only is the student of small means unable to borrow from this source the ordinary standard treatises which a competent Committee should provide: he can rarely find even the most important books descriptive of the natural history of the district in which the library is situated. I know one of these small libraries where the Librarian and Committee are so ignorant that, for lack of capacity to choose new books, they have confined their attention for many years to buying new copies of the old books that happen to have been worn out by prolonged and continual service. They have solved their difficulties by supplying what seemed to be in constant demand. I believe, in response to public ridicule, the Committee have lately ordered their Librarian (a hopelessly illiterate man) to read the 'Publishers' Circular' and the 'Athenæum,' so that he

may examine reviews and notices and direct their attention to anything worth buying. When such incompetence prevails in the selection even of general literature, in which all educated people are more or less interested, it is not surprising that less popular subjects should suffer; and if the Library Committees themselves do not seek the advice of the local Societies, the latter should certainly assert themselves more than they usually do, and insist that at least the more important of the larger educational works on science shall be properly chosen and made available for reference.

I am glad to learn from this year's Report of the Corresponding Societies Committee that the British Association has now decided, on certain conditions, to admit to our Conference Delegates from the local Societies which do not attempt more than the educational and missionary work of which I have been speaking. The importance of a Society's efforts for the advancement of science is by no means always measurable by the extent of its publications, and I feel sure that the next Conference will welcome among the Delegates from the newly *Associated* Societies several most useful members. In fact, I am inclined to agree with my predecessor of last year, that we should discourage rather than foster the multiplication of publications by local Societies. I entirely disagree with Principal Griffiths' proposal for the establishment of a new central Journal; but I do think that the tendency towards centralisation in the publication of nearly all the best work during the past two decades is a matter for great satisfaction among scientific men. It is still possible for those who are engaged in research, and who publish their results in the journals of the great Metropolitan Societies, to be at the same time most active members of the Field Clubs and Societies in the districts in which they reside. At the local meetings they have the opportunity of discussing their researches with their fellows before they are sufficiently advanced for publication; and I know several cases connected with my own branch of science in which the value of the completed work as published depends largely on the unreported Conferences which have been held upon it in the district where it was produced. There still remain, of course, several matters, chiefly of local interest, which it is advisable to publish on the spot, and these should form the bulk of a Society's annual issue.

Finally, I would allude to the main object for which this Conference appears to have been originally established. I think it was hoped that an annual meeting of Delegates would lead to more definite concerted action or co-operation between the local Societies in prosecuting certain specified lines of research. It was thought that proposals for organised work might be formulated, and that each active Society would accomplish its share of the programme. Year after year, however, suggestions have been made and inquiries have been started, in most cases, I believe, without any satisfactory response. In fact, the spirit of individualism seems to pervade our scientific Societies just as it pervades everything that is distinctively British. We cannot endure the feeling that we are merely units in the working of an organised machine; we all wish for freedom to follow our own inclinations. However large and important a Society may be, its main activities always depend on quite a small proportion of its members, and if they have gradually lapsed into a settled routine, it is difficult for any outside influence to make much alteration in their course. Moreover, I fear that the all-pervading mania for 'tit-bits,' which is so characteristic of this restless age, has penetrated even some of our

Societies, and reduced the amount of systematic and persistent plodding which is necessary for many important lines of research. An 'infinite capacity for taking pains' is much more fruitful than genius in not a few directions; and if the active members of a Society lack this quality, it is hopeless to expect them to assist in any extensive and organised scheme. Nevertheless, it seems to me that this Conference has other and perhaps equally important uses. It enables the chosen representatives of the various Societies to discuss many general questions in which all are interested; it brings together many active workers whose exchange of ideas, in private conversation quite as much as in public meeting, tends to the advancement of our common object; and if none of our resolutions have much binding force in plans for organised research, there cannot be any doubt as to the value of the union in friendship which results from the intercourse that is held.

At the conclusion of the Chairman's Address the Report of the Corresponding Societies Committee was read by the Secretary.

The Rev. T. R. R. Stebbing (Corresponding Societies Committee), in opening the discussion, said he would like to ask the opinion of the Delegates on the question of excursions, which had been touched on by the Chairman. The speaker in his younger days had attended a great many of these excursions in Devonshire, and had found that when, for example, he was collecting fossils, and wanted to set to work with hammer and chisel on some very hard rock, before he had had time to acquire his specimen all the rest of the members of the excursion were a mile or more away. The same thing happened when he was interested in collecting wood-lice. He did not know what remedy there was for people of like tastes with himself, unless they could be attended with a motor-car that would enable them to overtake the other members of the excursion! In the case of archæology it was different, as when anyone was discoursing on the ruins of a castle or an interesting church the whole party could study it, and the public at large were generally interested in such subjects, whereas in the study of natural history there were probably but very few members who cared for each special branch. While he was President of a local Natural History Society he had endeavoured to confine himself to natural history as much as possible, but he found that the lectures on architecture were more popular than any of their natural history subjects. Then one year they endeavoured to get specialists of repute to whom they paid considerable fees, and they had a very good time, but unfortunately were left in debt.

Mr. W. Dale (Hampshire Field Club and Archæological Society) said that he had had a good deal of experience, having been Secretary of a club numbering 300 members, and that he had the same difficulty as that referred to by Mr. Stebbing. They had no evening meetings, and he very much questioned whether evening meetings properly belonged to Natural History or Field Clubs. He thought a Natural History Society should take the field, and study nature in the open air. He found it convenient to arrange during the session at least three sectional meetings for the study of natural history, which they called Meetings for Nature-Study. In a Field Club there would always be a certain number of people who were devoted to architecture.

Mr. W. Gray (Belfast Naturalists' Field Club) said his Society numbered about 400 members, and he had been connected with it for over

forty years, having been Secretary for about fifteen years. With all due respect to the remarks that had been made, he believed that the serious work of a scientific Society could be combined with the more popular side, and he believed it should be the object of the local scientific Society to make real solid science popular.

Mr. Beeby Thompson (Northamptonshire Natural History Society) said it was useless to go out with an excursion with the object of doing any solid work. Those who were familiar with such excursions must be well aware that there was little time for actual work, and indeed he did not think the excursions were quite intended for that kind of thing. In all these excursions the chief object should be to show the members of the Society what was of interest in natural history, and if they wanted really to work they must go at some other time. Excursions afforded facilities for getting over much ground under a competent director ; but if one of the party came across anything to work at, he should go back and undertake the research at leisure. Many of the excursions which had been described as picnics might, after all, be very useful.

Mr. P. Ewing (Glasgow Natural History Society) said that his Society was not troubled with the expense of excursions, for their Excursions Committee arranged in such a way that no expense for the day should exceed half-a-crown. Their excursions usually took place on a Saturday, when reduced fares could be obtained. When organising an excursion they stated definitely what its special objects were. If it was for ornithology they named the birds that were common to the particular district they intended visiting ; if for botany, the plants that were likely to be seen ; and so on. Their Society divided itself into six sections under special leaders.

Mr. H. Coates (Perthshire Society of Natural Science) said that his Society made a standing rule not to accept any kind of hospitality, and this was now so well known that they were not asked to accept it. They sought to attain definite results by appointing leaders skilled in each subject. He would mention that within the last two years they had tried a new experiment which had been very successful, namely, the establishment of a Junior Section of the Society, consisting of the elder children of the schools who had gone in for a Natural History Essay Competition which the Society had instituted. Those who were successful were allowed to join the Junior Section, and there were a few excursions organised especially for them, each of which was led by an adult botanist, ornithologist, and so on, of the Society ; and they were specially enjoined to avoid interference with rare plants or animals. They were told to look but not to touch. These junior excursions had been found very successful, and had not developed into mere pleasure-excursions or picnics on the part of the children. They found that those who had gone in for the Essay Competition were really in earnest, and were glad of the help of the Society's adult members. In these ways Mr. Coates thought they had got over a few of the difficulties which the Chairman had referred to.

Mr. W. Marsh (Leeds Naturalists' Club) said he thought they must all be agreed as to the great value of the excursions of their Societies in Yorkshire. There was one of these local Societies in every town and practically in every parish. The Naturalists' Union is held together by its excursions. They organised eight in the year, and worked much upon the lines mentioned by Mr. Coates, going to a particular district where

they might expect to find a rare plant or insect, or for a particular geological purpose, and visiting a different division of the county at each excursion. They thought the picnic element was very strongly to be deprecated. As the group of Affiliated Societies consists of such Societies as undertake local investigation and publish their results, Mr. Marsh said he would like to ask whether the Committee had any condition as to the length of time which should elapse before the publication of such results. The Society he represented did not always consider it advisable to publish immediately, but held over anything of interest they might have until they had a sufficient number of papers to make a volume.

Mr. E. R. Sykes (Dorset Field Club) said he felt that his Society had become rather too much of a picnic society, but they were bent on mending their ways.

The Rev. W. Lower Carter (Yorkshire Geological Society) explained that the Yorkshire Naturalists' Union had a membership numbering 400 members and 3,000 associates. One important thing connected with the Society was the circular which it sent out. It contained notes on all the various branches of natural history of the district, given in a very brief form, with suggestions for looking for any plants, insects, &c., which have at some time been found but have not been seen for a number of years.

Mr. W. Whitaker (Vice-Chairman), referring to the question asked by Mr. Marsh as to the length of time given for the publication of reports of the different Societies, said he did not know that there was any definite rule on the subject, but his own idea was that they looked forward to something every year. But if a Society published a number every two years, and that was its method of publication, the Committee would not expect more. What they wanted to do was to keep the Societies in touch, and they would be inclined to look leniently on a little lapse in publication.

Mr. William Martin, M.A., LL.D., introduced the following subject:

The Law of Treasure Trove, especially in relation to local Scientific Societies.

The law of treasure trove has hitherto been the recipient of much condemnation. It is customary to find attributed to it the loss of valuable and, indeed, irreplaceable relics of bygone times. Defence of the existing system which allocates to the Crown, or the Crown's assignees, ownerless gold and silver accidentally discovered, or exhumed after search, is rarely heard. In fact, treasure trove is often, perhaps usually, considered as synonymous with 'melting-pot.' Thus, a maintenance of the law of treasure trove, we are told, 'is the best way to ensure that no such discoveries are made known, and to drive the finder to put all such treasures in the melting-pot.'[1] While but few submit practical suggestions for the amendment of the existing system—suggestions which the Government might have no hesitation in accepting—in many quarters a drastic alteration of the existing provisions is demanded.

Now a radical amendment of the law of treasure trove may, in view of the difficulties attendant upon legislation, not to mention the deep-rooted conservative instinct of lawyers and landed proprietors, be considered as almost 'beyond the range of practical politics.' May it not, then, be well to examine closely the present system, and to seek for amendment whereby, without offence to the susceptibilities of the various

[1] *Methods and Aims in Archæology*, by W. M. Flinders Petrie (1904), p. 183.

classes of society, much of the evil which the law is said to have engendered may be removed, and the way paved for an extension of the law more in consonance with modern feeling and enterprise?

With the view of showing that improvement might be accomplished by a more efficacious administration of the present law, and by employing to a greater extent the powers already possessed by the authorities, the following remarks are submitted for consideration.

The natural feeling that the apprehension, or the detention, of derelict property carries with it the right to possess, has, in mature systems of jurisprudence, given place to the knowledge that the right to possess by no means follows upon a detention. In some instances only, as is well known, does legal ownership follow the mere fact of possession or detention. When however there is found property uncared for, and lacking visible guardianship, the natural feeling that ownership should follow upon possession asserts itself so strongly as sometimes to stifle conscience. Efforts to find an owner are, in consequence, relaxed, and the assurance assumed that the law, when indeed a thought is given to it in such a case, is on the side of the finder.

In the case of gold and silver that have been put by with a view to reclamation and all knowledge of the deposit, or of the depositor, has vanished, the treasure accrues *in jure regali* to the Crown. When the Crown has transmitted its rights, treasure trove passes to the Crown's assignee.

By the law of treasure trove, then, the rights of the finder, whatever they may be, are postponed to those of the Crown, so that the law of first finding is ousted.

As already mentioned, it is deplored by many that the Crown steps in and secures the result of a find. It is assumed that were this exception to the law of first finding removed, the finder would proportionately be benefited by not being deprived of what in justice, it is said, belongs to him, and that the risk of a consignment to the melting-pot of unique articles, ancient and modern, would be so lessened as practically to be non-existent.

That the truth of this assumption is more than doubtful a cursory examination of the law of first finding will suffice to show. According to that law, the instances when the finder of derelict property becomes its owner by the mere fact of finding and taking possession are by no means common. Whether in the absence of all knowledge, actual or constructive, of the loser, a finder may assume the favoured position of owner depends largely upon the locality of the find and the position that the finder bears towards that locality. Probably the case which is most favourable to the finder is when the property has been lost on the highway or in a shop to which the public has had access. On the other hand, it is clear that those who are employed on private land cannot retain, as against the owner of the site, articles found during the course of their duties.

Further it is highly improbable that a mere tenant could legally hold finds from his landlord's estate as against that landlord. We are also all conversant with the difficulties of settling the rights of a finder as regards property found in quasi-public places, such as promenade piers, tramcars, and the like; for the fact of finding by no means concludes the matter. In the result it is unsafe to dogmatise upon the ownership of lost property when found by one to whom the owner is unknown or practically unknowable. A settlement of the question can only be had in this, as

in other connections, in the full light of all the circumstances of the finding.

Now, since among the essentials of treasure trove is that of an advertent depositing, it is unlikely that the treasure would come within these cases where, in the absence of a law of treasure trove, finds belong to their accidental discoverer. From the circumstances in which treasure trove was originally put out of sight and eventually lost to mind, it may safely be classed with those objects which become attached to the soil, and pass with it to the successive owners, of course supposing the absence of a special law to the contrary. The articles then constituting the find would certainly not belong to him who accidentally discovered their hiding-place; indeed a retention by him with the immediate intention of depriving permanently the owner of the soil of his property in them would be criminal. After the owner had gained physical possession of the articles, he would be at liberty to sell, preserve, or retain them, or to destroy them capriciously, advertently, or without a thought of his action. But, thanks to the law of treasure trove, precious metal may not be cast into the melting-pot precipitately unless the Crown has transferred to others its right to treasure trove. Even when an individual or a corporate body owns the right to treasure trove found on the demesne, articles which illegally have been withheld may eventually become the property of the finder owing to the action of the Statute of Limitations, six years being the prescriptive period (21 Jac. I., 1623, c. 16). Remembering the class of persons who usually discover treasure trove, the risk of the melting-pot under the general law is thus further increased. As against the Crown and its property the Statute of Limitations, of course, has no place.

Let us now for a moment briefly review the action of the Crown when treasure trove reaches the hands of the Treasury officials. First, as regards the finder, the Treasury promises remuneration to an extent proportionate to the value of the discovered articles retained by the Treasury. In the Treasury Circular of 1886 no allusion is made to the owner of the soil or to any other person in whom, according to the law of first finding, the articles should vest. Secondly, as regards the articles, these when received are sent to the British Museum or to some other institution. In the event of the articles not being required they are returned to the finder.

It may now be asked, In what way would the abolition of the law of treasure trove subserve the interests of archæology? It is clear that the finder would not be benefited, for experience shows that a finder as a rule disposes of his find to the first stranger who offers what the finder in his ignorance considers adequate. Would the public be the better? Rarely would treasure find its way into public museums; at any rate not to the extent to which it is now possible. At the best the treasure would be placed in a private collection, or, what is worse, would be passed from one to another until all knowledge of the locality of the find and of the attendant circumstances was lost. Surely it is not less law of treasure trove that we want, but more. Its provisions should be extended so as to include 'with adequate safeguards and inducements, all objects of distinct antiquarian value, whether of gold or silver, or not, and irrespective of any requirement of proof or presumption as to their having been originally hidden.'[1]

[1] *Juridical Review*, vol. xv. p. 277.

On the present occasion, however, it is only incidentally that I would urge, if need be, an extension of the law. My object is rather to indicate how by a mere departmental instruction, at the cost of printing and postage alone, the risk in England and Wales of loss of objects of antiquarian value might be considerably lessened. I am alluding to a suggested recognition by the Treasury of its servants, viz. Post Office officials, who are to be found in every village and town throughout the country, as the accredited custodians for the time being of all articles of antiquarian value, which having been brought to them purport to have been discovered in the neighbourhood. Further, I am suggesting the dissemination through those officials, as, for instance, by notices and posters, of the liberal terms which the Treasury has promised to finders.

As regards the first point, the Post Office for many reasons is to be preferred to the police officials. The reasons for the preference, even if not obvious, need not here be enumerated. With respect to the practicability of the scheme suggested, I have been informed privately by an official of the Post Office that there could be no objection from a practical point of view to the receipt of treasure trove and other articles, provided that they were immediately forwarded to the postmaster of the district in which the receiving office lay. On the delivery by the finder of the article at the village or other post office he should be given a receipt with counterfoil and an envelope addressed, say, to the Treasury Solicitor. The receipt could then be placed in the envelope and posted by the finder himself, who would retain the counterfoil. In this way the confidence of finders would be gained, for they would be assured of the safety and acknowledgment of their deposits at the Post Office.

As regards the second point, the publication of the Treasury promise of remuneration to the finder, we have fortunately to hand the precedent set by the Royal Irish Academy, which has for many years been in the habit of posting notices, illustrated and otherwise, throughout Ireland.

The practice, too, of the Corporation of the City of London, to whom the franchise of treasure trove was granted by the first charter of Charles I., may be instanced. Mr. Welch, F.S.A., Curator of the Guildhall Museum, kindly informs me that the Corporation inserts in all its building leases a clause claiming coins and other objects of value which may be discovered on the site. As Curator of the Museum, Mr. Welch unofficially secures, through the clerk of the works, the co-operation of the workmen in all important improvements, with whom he agrees for liberal payment for all objects worth securing for the Museum.

As regards the County Council of London, who, I believe, have not had the right to treasure trove conferred upon them, a notice is posted upon buildings in course of demolition, and upon sites which are being excavated by them. By this notice a reward is promised to workmen who discover objects of geological and archæological interest, which, being the property of the Council, are handed over to the foreman or clerk of the works.

With precedents such as these to hand, it would not be difficult for the Treasury to scatter broadcast its notices concerning the remuneration offered to finders of treasure trove. That the Treasury has issued such a notice comes as a surprise to many, for the general feeling I find, even among the educated classes, is that no reward is given to finders. I myself on applying this year at the Treasury for a copy of the Circular issued by the Treasury in 1886, was informed that 'no instructions are

issued by this department as to the remuneration offered to finders of treasure trove.' On further correspondence taking place, I was told that the Treasury had not 'expressed any intention of departing from the general principles on which they have hitherto acted in dealing with treasure trove.'

By the Circular of 1886 'the *antiquarian* value of such of the coins or objects as are retained or sold,' less a deduction of 20 per cent. of the antiquarian value of the objects retained, or of 10 per cent. of the antiquarian value of all objects discovered, was promised to the finders.

The finder alone is dealt with by the Circular, there being no mention in it of the finder's employer or of the owner of the soil on which the treasure has been discovered. In this respect, then, the finder is in a better position than he would in all probability have occupied had his rights been those arising merely from the law of first finding. Finders as a rule are not aware of the true value of what they discover. Consequently it is to their interest to abstain from a sale to a passer-by or to a casual stranger, who usually has some good idea of the transaction in which he is engaged. If it were known that a finder's interests were enhanced by a delivery of the articles into proper custody, much of what otherwise would be lost or cast into the melting-pot would be preserved for future generations.

I think I have now placed my views sufficiently before the Committee to enable me to sum up what I suggest is suitable for discussion, viz.:—

'That a union of antiquarian and allied Societies is desirable for the purpose of submitting to his Majesty's Commissioners of the Treasury one or more resolutions which relate to the amendment of the Law of Treasure Trove and of the administration of that Law.'

The specific amendments with which the resolutions should be concerned are the taking of the necessary steps for bringing to the knowledge of the public, as, for instance, through the medium of the Post Office—

(1) The importance of the preservation of treasure trove;
(2) The remuneration which is offered to finders; and, if considered expedient,
(3) The desirability for the remuneration offered to finders being put upon a statutory basis; and
(4) An extension of the Law of Treasure Trove so as to cover other relics of antiquity, thereby bringing the Law into harmony with what is believed to be the Law of Scotland.

Finally, whatever resolutions were arrived at, suitable explanations of the reasons that led up to the resolutions and practical suggestions for carrying out the objects aimed at should be appended when they were forwarded to their destination.

Mr. T. Sheppard (Hull Scientific Club and Yorkshire Naturalists' Union) said that undoubtedly the law as it stands at present is greatly misunderstood, and from some little experience he had found that anything that was discovered was looked upon as Crown property, and both the owner of the land and the actual finder expected nothing whatever in return. The suggestion that had been made with regard to the Post Office regulations, and that all antiquities should be looked upon as treasure trove or Crown property, was one that required careful consideration. Speaking as the Curator of a comparatively small museum (Hull), he could say that the number and quantity by weight of the articles

brought to him as 'antiquities' was simply appalling. Personally he felt that in consequence of the organisation of such Societies as were connected with the British Association and the local museums, which were now fairly on the alert, the disposal of local antiquities, other than gold and silver, might be fairly left as at present. The man who finds anything is generally the least qualified to know anything about its value, and often thinks a thing of priceless value when it is of no value whatever, and *vice versâ*. In Hull they had tried something similar to the rule which is in practice in London in reference to the finding of treasure during the demolition of property, but it had not acted satisfactorily. The fact that the Hull Corporation had a clause put in the agreement that any objects found upon the site were to be given up to the Corporation simply gave the men the idea that they were not entitled to anything; and consequently, as soon as anything was picked up it was 'sneaked' into the pocket and probably sold to anybody who happened to be on the spot. The result was that, notwithstanding the official statement in the agreement, and notwithstanding the fact that the foremen were told to look out for specimens, very few of them were really given up. He would strongly support any resolution to make the law of treasure trove better known than it is at present. He did not see the advisability of including all antiquities, but thought something might be done to let the local museums have a share.

Mr. J. Hopkinson (Hertfordshire Natural History Society) said that while it was pretty generally known that the finder got the bullion value of the article found, it was not generally appreciated that now, according to the regulations made in 1886, on the suggestion of Sir John Evans, the finder got the archæological value, which may be considerably more than the bullion value. He quite agreed with the suggestion made that there should be some notice to that effect put up at the post offices all over the country; but the deduction of 20 per cent. of the value would, of course, act as a deterrent from sending the objects found to the Treasury. He thought the law at present bore most unjustly on local museums, for in his opinion the local museums should always have the first right of purchasing the objects at their value. He thought it was very hard upon a locality that valuable things found in it should have to go to the British Museum.

Mr. W. Gray (Belfast) said he thought something should be done to make people know that they would be remunerated for anything they found. Reference had been made to the Circular issued by the Royal Irish Academy, and it would be very interesting for Societies like theirs to know the result of that Circular. He knew that a Circular issued by his Society to the National Schools had been an absolutely dead letter.

Mr. W. Taylor (Elgin Literary and Scientific Society) said he would like to suggest that, whenever things were found about the value of which there was any doubt, they should be sent to the proper authorities for investigation.

The Rev. J. O. Bevan (Woolhope Naturalists' Field Club) asked whether it would not be desirable to enter into correspondence with the Society of Antiquaries on the subject before any formal action were taken, as possibly it possessed some information of which the Conference might be ignorant, or it might have taken action in relation to the matter. Mr. Bevan said that as it was possible for the Crown sometimes to delegate its rights for the possession of treasure trove to some other

body, as it had done in the case of the City of London, he would like to know if it had been done in the case of other bodies, such as the Duchies of Lancaster and Cornwall. Would there be any special provision there?

Dr. Martin explained that there were two classes of delegation of the rights of treasure trove. The Corporation of the City of London had the right to treasure trove in virtue of a charter of Charles I.'s time; and as regards the second class of case, he instanced that of the Royal Irish Academy. It was simply, so far as his knowledge extended, the agent of the Crown for its collection and for its exhibition, so that the Royal Irish Academy was directly under the control of the Crown as regards treasure trove. The City of London was not an agent of the Crown: it was the principal in the matter of treasure trove. There were many instances throughout the country where a franchise had been handed over or assigned to the Lords of the Manor. In the case of the Duchy of Lancaster (speaking under correction) he was almost certain that it had this right to treasure trove from time immemorial. As regards the Duchy of Cornwall, he had no information. There were many instances where the right to treasure trove had been assigned in virtue of charters which are still in existence. In reply to a question by Mr. Stebbing as to the law in regard to treasure cast up by the sea, Dr. Martin said it was certainly not treasure trove, but probably belonged to the Crown under the technical expression Droits of the Admiralty.

The Rev. R. Ashington Bullen (Holmesdale Society and S.E. Union) remarked that the famous gold cup found at Rillaton in Cornwall seemed to have come into the possession of Queen Victoria at a time (1837) when there was no Duke of Cornwall. It was exhibited at the Royal Archæological Institute in 1867 by permission of the Queen and the Prince of Wales. The gold lunettes found at Harlyn in Cornwall in 1866 were claimed by the Duke of Cornwall in his own right.

Mr. W. Morris Colles (Director of the Authors' Syndicate) then introduced the following subject:—

The Law of Copyright as affecting the Proceedings of Scientific Societies.

From the proof of 'Papers relating to the Question of Copyright' which had been placed in his hands since he entered the room, he gathered that the points which called for discussion were, mainly, the relations between Scientific Societies, their members, and the public with reference to papers communicated to, and printed by, or delivered before the Societies. These naturally resolve themselves into two classes—namely, public and private. As regards papers which were published in the general sense, by being placed on sale, the ordinary rules of copyright law applied; but papers which were only privately printed were indistinguishable from papers existing only in manuscript, as they were not published at all, and the copyright, unless assigned, remained in the authors by common law.

Some of the Societies had, he noticed, bye-laws declaring the copyright of all accepted papers to be vested in them, but it was questionable whether these bye-laws were in themselves sufficient to give the Societies a good title to the copyright in such papers without an actual assignment (which could be prepared by their legal advisers) in such a form as to hold good either against the members themselves or against infringers. This was, in short, a case like so many arising under the Copyright Acts, which could only be met by special contract. Neither Section 18 of the Copy-

right Act of 1842 nor the clauses of the Copyright Bill of 1900, affecting 'collective works,' could be held to apply. It had been suggested that Scientific Societies should endeavour to procure some special legislation when the Bill of 1900 was proceeded with; but Mr. Colles expressed it as his opinion that it would be found impracticable to obtain any additions to the Bill of 1900 that would meet the case, and believed it would still be found necessary to deal with this question as a matter of special contract outside the Statutes. The temper of Parliament towards the Copyright Question was such that it was always peculiarly difficult to obtain exceptional rights, nor were such rights capable of being easily defined or made generally applicable.

Mr. Harold Hardy dealt with the position of the author of a paper which might be read at a meeting of a Scientific Society. This, he said, was partly affected by the law of copyright in books and partly by the law relating to copyright in lectures. While the paper was unread or unpublished the author was entitled to copyright in his literary composition, and could restrain anyone from publishing it: he was in the same position as the author of a book in manuscript. Again, when the paper was read before the Society, if the audience consisted merely of members of the Society, or a limited number of persons invited and admitted by ticket, that was not regarded in law as publication, and the author would still be entitled to copyright, as in an unpublished manuscript. If, however, a paper was read before a meeting to which the public generally were admitted, the author could only protect his copyright by adopting one of two methods recognised by the law. He could, of course, print and publish his paper before oral delivery and register it as a book at Stationers' Hall. In that case he would enjoy the same copyright as attaches to a published book. Another method was a very curious provision of the law, and one which was unreasonable at the present day. The law provided that if the author gave two days' notice to two magistrates living within five miles of the place where the paper was to be read, he would have protection for his copyright in the work for twenty-eight years. That was a provision which was generally unknown and consequently ignored. It was a senseless provision, because it imposed no duty upon the magistrates to take any steps with regard to the notice. They might lock it up in the pigeon-holes of their desks, and, instead of being a warning to the public that the author's rights were preserved, the public generally knew nothing at all about it. This notice to the magistrates, therefore, ought to be abolished, and he was glad to find that the recommendation of the Royal Commissioners with regard to it had been adopted in the new Copyright Bill. Another amendment he suggested was that the law should give protection for the oral delivery of lectures. A lecture might be described as a literary composition adapted for communication to the public either by printing or by oral delivery. Both those qualities had a commercial value and ought to be protected; but at the present time there was no protection for the right of publishing a lecture by oral delivery as distinct from the copyright. The law relating to lectures should be made somewhat analogous to the law in respect of dramatic compositions. The author of a play had copyright and the right of representation in public. The right of representation of a play might be compared to the publication of a lecture by an oral delivery, or the 'lecturing right,' as it was called in the Copyright Bill of 1900.

Mr. Longden, representing the Institution of Mining Engineers, said that so far as the 'Transactions' of the Institution of Civil Engineers are concerned they are safely guarded. The Institution has rules by which if anybody communicates a paper to it that paper becomes its property; but it appeared to the speaker that the reason why its papers are so safely guarded is because it takes an interest in the matter and follows it up. If anybody chooses to pirate the information which has been communicated, the culprit hears of it and is stopped. The Institution of Mining Engineers found it difficult to prevent people from pirating the information which had been communicated. He thought the rules were almost identical in both Societies, and it seemed to him it was largely a matter of laxity. But so far as the British Association was concerned, he took it that the Association would rather the information was circulated than kept back.

The Rev. W. Lower Carter (Yorkshire) wished to know what position the British Association took as regarded the abstracts which it published. There had been a discussion as to whether it was free for anybody to reprint, or to print any such part of them as they chose, without any reference to the British Association or to the author.

Dr. H. R. Mill (Corresponding Societies Committee) said he did not think a scientific man wished to keep the result of his investigations to himself, once it was given to a Society, whether one of the learned Societies publishing transactions in the ordinary way or the British Association publishing abstracts only. A scientific man surely desired that his paper should be as widely known and as much quoted as possible. That was Dr. Mill's position, and he thought that any question of retaining copyright in scientific work once given to the public was absurd. He looked upon the British Association as an Association intended for the dissemination of science, one of whose objects was to make known as widely as possible the information collected.

The Rev. T. R. R. Stebbing said he quite agreed with Dr. Mill that scientific men were glad to find their papers sufficiently popular to be reprinted.

Second Meeting, October 31.

Dr. A. Smith Woodward, F.R.S., in the Chair.

The Corresponding Societies Committee were represented by Mr. W. Whitaker, the Rev. J. O. Bevan, Dr. J. G. Garson, Mr. John Hopkinson, Mr. T. V. Holmes, and Mr. Rudler.

Professor G. S. Boulger, F.L.S., F.G.S., introduced the following subject:—

The Preservation of our Native Plants.

Plants are in danger of extermination from inevitable natural causes, such as the encroachments of the sea and the increasing density of population, with its concomitant clearing, draining, and building. Among avoidable causes of loss the more important are the thoughtless excesses of children, tourists, and botanists, and the work of trade-collectors. The demands of artists have led to much local extermination of the sea-holly, and the fruitless endeavours of amateurs to cultivate our terrestrial orchids seriously endanger some species. Nurserymen, who certainly do not cultivate orchids, offer them for sale, just as clergymen and others

in the Lake District, or other districts still rich in ferns, advertise collections of these plants. It is mainly plants, such as primroses and ferns, which can be obtained in large quantities that appeal to the trade-collectors; but these men, who now range far afield from London or other large towns, are often merely the *employés* of large wholesale firms. Botanists, who ought to know better, are often recklessly wholesale in their collecting, rooting up numerous specimens of non-variable species, partly for the purpose of exchange. Even the gathering of the blossom may endanger the continuance of species which are annual, such as *Blackstonia perfoliata*, by preventing the formation of seed.

Among protective measures are the concealment and enclosure of the localities of rarities, the cultivation of wild forms, transplanting them from places where they are in danger, educational or moral methods, and legislation. Enclosure, unless a keeper be employed, may only direct attention to the locality of some rarity: it must be costly, and can be only of very limited application. Much may be done by the cultivation of rarities in gardens near by, so as to supply tourists, as M. Correvon grows edelweiss and other Alpines at Geneva. Small gardens near Ben Lawers, in the Lake District, and at the Lizard would be very valuable. Ultimately we must depend mainly upon the development of a general sentiment in favour of the conservation of our natural beauties, and nothing will conduce to this end more than educational measures. We must educate our teachers. A leaflet might be distributed among them stating the case; and perhaps a 'reader' might be prepared intermingling pleas for plant protection with interesting accounts of plants and plant-life. The clergy, or other managers of school-treats, might well represent to the children beforehand such simple principles as that one cannot both eat one's cake and have it; that some flowers should be left to form seed to grow into new plants; and that some should be left for others' enjoyment.

As the results of education must be tardy, and the existing law is inadequate, legislation appears necessary. It is at present necessary to prove damage: it is difficult to secure the co-operation of landowners and the police; and the powers of the Home Secretary and of the County Councils as to the making of bye-laws are not sufficiently clear. It is proposed to introduce a Bill on the lines of the Wild Birds' Protection Acts, applying only to persons over fourteen years of age as principals, and exempting occupiers of land and those authorised by them, but authorising the scheduling of species, districts, or whole counties.

The Rev. R. Ashington Bullen, on discussion being invited, said there were two points which had not been touched upon by the Professor. One was the prevalence of incendiary fires. He had reason to believe that the whortleberry, which had been trying to grow in his district (near Woking), had been entirely destroyed during this last summer. His daughter had found some good specimens of this little plant, almost a stranger in that particular part of the country, which in the course of a few years would have acclimatised itself, but which was now completely destroyed. The other point which the Professor had left out was the mischief done by golf-links. At Reigate a beautiful feature of the country had been destroyed in the filling up of a bog, which doubtless had also resulted in the destruction of the sundew.

Mr. W. Watts (Manchester Geological Society) said the district from which he came suffered immensely from the depredations alluded to by

Professor Boulger. Daffodils, which a few years ago grew abundantly in a wood in front of his house, were now almost extinct owing to the depredations of collectors, who came every spring and carried them away. Many fir-trees were also subject to destruction. With reference to the picking of blackberries, he had done what he could to induce farmers to prevent the people from gathering them, but the farmers dare not interfere, as if they did, the coping on their walls, &c., would be pushed down. It was also pitiable to see the way in which young trees were dug up. It would be a great benefit if something could be done to prevent cyclists and others from breaking the trees and taking the bloom away with them.

Mr. P. Ewing (Glasgow) said he would speak first upon the clergy. Speaking for Scotland, the English clergy were the worst enemies they had. A great many plants had become extinct owing to their depredations. As to the market gardener, he did not mind him so much, as he generally left something of the plants behind. He had known districts supposed to be cleared by these men in which the plants had come back again. The thing he objected to was the extermination of plants that would not reproduce themselves. He spoke of the Alpine flowers. He thought legislation was a difficult matter, and, so far as he could gather, the Bill proposed left the owner free to allow people on his land to get anything they wanted.

Mr. Longden (Stanton) said he did not think there would be any chance of getting legislation on the subject next year, but it appeared to him there were means, through the school teachers, of preventing the destruction of wild flowers. A short circular, he suggested, should be sent out in the first instance to the school teachers calling their attention to the subject, and, perhaps, putting them in communication with someone who would get out a book with simple English names, illustrated, and with interesting stories, if possible, with reference to the plants, so that the children should be interested. He thought this would be a move in the right direction. He also thought the practice of herbaceous gardening was an immense improvement on carpet gardening, and one way in which wild flowers could be preserved.

Mr. H. Coates (Perth) thought that the local Societies were very much indebted to Professor Boulger for his paper, as he regarded this as one of the most important subjects they could possibly discuss, and one which they were eminently qualified to deal with, because they knew the local conditions in the different districts and might be able to suggest remedies. Mr. Coates said he was very much in favour of one suggestion, which he hoped his Society might be able to carry out, and that was with regard to the establishment of gardens for the cultivation of plants which are in danger of extermination. Professor Boulger had specially referred to Ben Lawers in that connection, and Mr. Coates saw no reason why his Society should not take the initiative in doing something in that way. The Perthshire Society had always looked upon Ben Lawers as specially its own preserve, and had always jealously guarded it, and he could safely say that the botanists of his Society had done what they could. Professor Boulger had also referred to the practice in England of collecting large numbers of the more showy plants, but Mr. Coates thought that did not obtain very much in Scotland—or, at any rate, in Perthshire—probably because there was not the same ready sale for them there as in London. What they suffered most from was the local professional collector, who collected rare plants to sell to tourists. He knew one locality which had

been completely stripped of certain rare flowers, and other plants were in danger of extermination in the same way. He thought one of the most valuable suggestions which had been made was with regard to teaching teachers. In the locality he represented a special effort had been made to get teachers interested in the work of the Society, and a large number, both of the head masters and some of the more intelligent assistant teachers, were members of the Society. In this way he thought local Societies might do a very great deal in trying to encourage the teachers to take up this subject intelligently, and especially to point out the great danger of the extermination of rare plants. With regard to the suggestion of gardens for cultivation, the only difficulty he saw was that of finding a suitable situation where the conditions of soil would be precisely similar to those in which the plants grow.

Mr. W. Gray (Belfast) considered that the object of a Society like his was not so much to preserve rare plants as to prevent plants from becoming rare. As it was, the flowers and ferns which used to decorate the roads and hedges were being entirely obliterated. He thought nothing would prevent these depredations but law. They might talk about moral suasion and the influence of the clergy and of teachers, but they would never touch the main point unless a law was made to prevent the destruction of other people's property without their permission, and then, in doing this, care must be taken to give facilities for the scientific collector to carry out his function.

Mr. W. Marsh (Leeds) said he thought they would agree that, if legislation could be obtained to protect these beautiful flowers and ferns, it was a very desirable thing ; but in the meantime the damage was being done and legislation was slow, and he would immensely like to see the idea of issuing a circular carried out. Nature-study was becoming an important part of education. He thought they had 4,000 children in Leeds, who were beginning to take an interest in wild flowers, and as these went out in the country the depredations were likely to be serious.

Mr. J. Hopkinson (Watford) gave an account of the depredations in the neighbourhood of St. Albans of dealers in ferns some thirty years ago, when several species which then adorned their lanes and woods were absolutely extirpated. He thought the idea of a circular a good one and that it should be carried out before any legal Act could be obtained, which would take time.

Mr. Whitaker (Croydon) said he would like to say a word on the other side. He thought collectors had been somewhat unfairly treated. They were not the only offenders. The offenders are the people who buy the things, and those are the people who ought to be got at. It was no use getting at the servants : they must get at the masters. Who were they ? In the first place, there were the artists. A great deal was also due to the craze people had for filling their rooms with cut flowers. Where did the fault lie ? He would quote the words of a very old authority, 'The woman did it.'

The Chairman said he judged that the general wish of the meeting was that the subject should not be allowed to drop, and that the matter should be brought before the different Corresponding Societies for them to do what they could in the next year by bringing the subject before the proper authorities. He would like to add one word to what had been said, and that was in reference to the action of a certain Moss Litter Company. He did not know many places where they were working, but

they had completely ruined one of the most prolific floras near his native town. He could also endorse what Mr. Watts had said with regard to the farmers not daring to exert their power for fear of reprisals.

Professor Boulger, in reply to the various remarks, said that owing to the question of time he had purposely said little or nothing on what had been done in the matter in America, where they had set us a very good example; but he ventured to make the suggestion that if in a comparatively new and thinly populated country, such as the United States, actual measures of legislation besides other measures were necessary, they were obviously far more necessary in a densely crowded old country like our own. He did not quite understand what was the cause of the incendiary fires of which Mr. Bullen had spoken, although he could quite understand the damage that would be done. He learned that *Eryngium campestre* had been exterminated by golf at New Romney, Kent, and from the other side of the Atlantic, at Staaten Island, a rare species of *Clematis* is in immediate danger of extermination from the same cause. The sundew at Reigate is an additional example. He saw that the meeting generally was fully in sympathy with the suggestion of a circular, possibly connected with the publication of a 'reader.' The latter would be a very simple matter, and he fully agreed that legislation was entirely inadequate. A public sentiment must be created. The only question was whether they were to wait for the sentiment to grow or whether they were to assist its growth by means of legislation? His idea was that the two things had better go on *pari passu.*

With regard to what Mr. Coates had said on a special situation for the cultivation of Alpine flowers, many people managed to grow most Alpines in non-Alpine situations, and he believed that by taking proper precautions, such as by covering up the plants in winter, there need be no difficulty. He thought it would be a particularly good thing if the Perthshire Society made some arrangement for the cultivation of Ben Lawers plants, and if somebody in the West of England could be got to establish a garden for the plants of the Lizard. As to local culture there was another way in which it could be dealt with. He noticed when he was in Cheddar a little while ago that the cottagers root up and pick *Thalictrum montanum*, which might be a little difficult of cultivation, but that they did not do so with regard to the Cheddar pink. The pink is mostly cultivated in gardens. At present, however, the localities where these plants still linger are very difficult of access.

The danger with regard to nature-study was a very great one, and there was no way of preventing rare flowers from being picked except by not taking people to the localities, or by keeping the knowledge to oneself. It was for this reason he cordially joined some years ago in protesting against the foolish action of the Essex County Council in suggesting an excursion of school teachers to the localities for rare plants in the New Forest. As to what Mr. Whitaker had said about women, it was not encouraging to think that what had been done to protect birds had not been assisted by women. They still wore egrettes, and it could not be due to ignorance, having regard to the vast amount of talking and the amount of literature which had been produced on the subject. He was sorry to hear what the Chairman had to say about the Moss Litter Company, and was afraid that this, like the drainage of agricultural land, was something that could not be prevented. He could quite understand that a great many of our fen plants might be destroyed in this way, and

it seemed a most regrettable thing, as our marsh plants are among the most interesting natives, and by the drainage of the land they are becoming every year more rare. With regard to the proposed Act, he did not suppose it would do its work unless backed by public interest. He agreed with the suggestion that a circular should be issued as soon as possible, and steps be taken to have also a 'reader.' This, however, he did not think sufficient; and though once of a different opinion, he now believed legislation to be absolutely necessary.

Reports from the Sections.

The Secretary explained that a letter had been sent to the Recorder of each Section asking for information as to any local work which could be usefully undertaken by the Corresponding Societies during the ensuing year. The response to this letter had not been very encouraging, but such letters as had been received were read.

Mr. J. Lomas, representing Section C (*Geology*), had asked the Delegates to assist the following Committees, viz.: 1. Erratic blocks; 2. Trias Committee; 3. Geographical and geological names. Although the first Committee has been at work for many years, there are still parts of England from which no reports have yet been received. The Trias Committee seeks to record all the fossils which have been found in the Triassic rocks of Great Britain, to trace type specimens, and to collect exact data as to the horizon at which the specimens were found. Photographs of sections, footprints, or other fossils would be gladly acknowledged by the Secretary. The third Committee is one which can properly discharge its duties only by the co-operation of the various local Societies affiliated to the British Association.

Dr. H. W. Marett Tims, Secretary of Section D (*Zoology*), wrote explaining that he had not been able to communicate with the Sectional Committee, but on his own responsibility suggested the following subjects as worthy of local attention: 1. A systematic study of the freshwater Plankton of East Anglia; 2. A study of the Rotifera of East Anglia.

Dr. A. J. Herbertson, Recorder of Section E (*Geography*), called attention to the Committee on local names for geological and topographical features, and suggested that the Corresponding Societies might also assist by sending data as to the composition and value of rainfall and discharge of rivers and lakes for a new Committee. Any results of investigations relating to local climate and health might be sent to another new Committee, of which Sir Lauder Brunton is Chairman, dealing with the effect of climate upon health and disease.

Mr. J. Barcroft, Recorder of Section I (*Physiology*), inquired whether the local Societies could aid the last-named Committee in considering the effect of climate on disease. One of the first objects of the Committee must be to get in touch with meteorologists on the one hand, in order to secure accurate data concerning climate, and with medical societies on the other hand, in order to get statistics about disease.

The Rev. J. O. Bevan ventured to ask the support of the Delegates for the consideration of questions involved in relation to the Committee on the quantity and composition of rainfall, and of lake and river discharge. It referred to the ratio of the discharge of the river to the rainfall in particular districts, and the position of the discharge in relation

to the sediment which it might bring down. This important Committee took the whole world for its range.

Mr. John Hopkinson said that no new Committee was needed for ascertaining the amount of rainfall for this country, as that was already thoroughly worked up by Dr. H. R. Mill, who had an army of about 4,000 observers whose returns were published annually in 'British Rainfall'; and he was sure it would be greatly to the advancement of science if all returns were sent to Dr. Mill rather than that there should be a separate department dealing with the same subject.

The Rev. J. O. Bevan explained that the work of the Committee he represented was not to determine the amount of the rainfall, but to determine the ratio of the river-discharge to the whole of the rainfall in particular districts, which of course involved questions relating to the position of the soil and the amount of water that is absorbed by the soil. It had to determine these particular ratios, and not to determine the absolute amount of rainfall; and another thing was to determine the character of the solution in the discharge at the mouth of the river in relation to the different strata in the area over which the rainfall would go.

Dr. H. R. Mill, a member of the new Committee, wrote: 'The object of the new Committee is not to divert the rainfall records of this country from the existing publications, where they are most conveniently accessible, but to collect all published notices and to secure new observations of the composition of the dissolved matter in rain and river water, and also to deal with the subject of river-discharge. The work proposed does not overlap with that of any previously existing Committee.'

Mr. W. Whitaker proposed a vote of thanks to the Chairman, which was carried by acclamation, and the proceedings then closed.

The Corresponding Societies of the British Association for 1905–1906.

Full Title and Date of Foundation	Abbreviated Title	Head-quarters or Name and Address of Secretary	No. of Members	Entrance Fee	Annual Subscription	Title and Frequency of Issue of Publications
Andersonian Naturalists' Society, 1885	Andersonian Nat. Soc.	204 George Street, Glasgow. R. Barnett Johnstone & T. Nisbet, M.A.	290	None	2*s.* 6*d.*	Annals, occasionally.
Bath Natural History and Antiquarian Field Club, 1855	Bath N. H. A. F. C.	J. Langfield Ward, Royal Literary and Scientific Institution, Bath	70	5*s.*	10*s.*	Proceedings, annually.
Belfast Natural History and Philosophical Society, 1821	Belfast N. H. Phil. Soc.	Museum, College Square. R. M. Young, M.R.I.A.	210	None	1*l.* 1*s.*	Report and Proceedings, annually.
Belfast Naturalists' Field Club, 1863	Belfast Nat. F. C.	Museum, College Square. George Donaldson	410	5*s.*	5*s.*	Report and Proceedings, annually.
Berwickshire Naturalists' Club, 1831	Berwicksh. Nat. Club	Rev. J. J. M. L. Aiken, B.D., Manse of Ayton, Berwickshire	400	10*s.*	7*s.* 6*d.*	History of the Berwickshire Naturalists' Club, annually.
Birmingham and Midland Institute Scientific Society, 1859	Birm. & Mid. Inst. Sci. Soc.	Alfred Cresswell, Birm. and Midland Inst., Paradise Street, Birmingham	143	None	10*s.* 6*d.*	Records of Meteorological Observations, annually.
Birmingham Natural History and Philosophical Society, 1858	Birm. N. H. Phil. Soc.	Norwich Union Chambers Congreve Street, Birmingham. W. P. Marshall and W. B. Grove, M.A.	174	None	1*l.* 1*s.*	Proceedings, occasionally.
Bristol Naturalists' Society, 1862	Bristol Nat. Soc.	S. H. Reynolds, M.A., University College, Bristol	162	5*s.*	10*s.* and 5*s.*	Proceedings, annually.
Buchan Field Club, 1887	Buchan F. C.	J. F. Tocher, F.I.C., 5 Chapel Street, Peterhead	170	5*s.*	5*s.*	Transactions, annually.
Burton-on-Trent Natural History and Archæological Society, 1876	Burt. N. H. Arch. Soc.	B. L. Oswell, 5 Balmoral Road, Burton-on-Trent	200	None	5*s*	Annual Report. Transactions occasionally.
Canada, Royal Astronomical Society of, 1884	Roy. Astr. Soc. of Canada	Canadian Institute Building, Toronto J. R. Collins	150	None	2 dollars	Transactions, annually.
Caradoc and Severn Valley Field Club, 1893	Car. & Sev. Vall. F. C.	H. E. Forrest, 37 Castle Street, Shrewsbury	185	5*s.*	5*s.*	Transactions and Record of Bare Facts, annually.
Cardiff Naturalists' Society, 1867	Cardiff Nat. Soc.	William Sheen, M.S., 2 St. Andrew's Crescent, Cardiff	410	None	15*s.*	Transactions, annually.
Chester Society of Natural Science, Literature, and Art, 1871	Chester Soc. Nat. Sci.	Grosvenor Museum, Chester. G. P. Miln and W. F. J. Shepheard	1028	None	5*s.*	Report and Proceedings, annually.
Cornwall, Royal Geological Society of, 1814	Cornw. R. Geol. Soc.	The Museum, Public Buildings, Penzance. John B. Cornish	98	None	1*l.* 1*s.*	Transactions, annually.
Croydon Natural History and Scientific Society, 1870	Croydon N. H. Soc.	Public Hall, Croydon. G. W. Moore	200	None	10*s.*	Proceedings and Transactions, annually.
Dorset Natural History and Antiquarian Field Club, 1875	Dorset N. H. A. F. C.	Rev. Herbert Pentin, M.A., Milton Abbey Vicarage, Dorset	361	10*s.*	10*s.*	Proceedings, annually.
Dublin Naturalists' Field Club, 1885	Dublin N. F. C.	J. de W. Hinch, National Library of Ireland, Dublin, and F. O. B. Ellison, B.A.	130	5*s.* Assoc. none	5*s.* Associate 2*s.* 6*d.*	'Irish Naturalist,' monthly; Report, annually.
East Kent Scientific and Natural History Society, 1857	E. Kent S. N. H. Soc.	A. Lander, The Medical Hall, Canterbury	92	None	10*s.*	Transactions, annually.
Eastbourne Natural History Society, 1867	Eastbourne N. H. Soc.	E. J. Bedford, Anderida, Gorringe Road, Eastbourne	120	2*s.* 6*d.*	7*s.* 6*d.*	Transactions, biennially.
Edinburgh Geological Society, 1834	Edinb. Geol. Soc.	India Buildings, Edinburgh. John A. Johnston	200	10*s.* 6*d.*	12*s.* 6*d.*	Transactions, annually.
Elgin and Morayshire Literary and Scientific Association, 1836	Elgin Lit. Sci. Assoc.	T. P. MacDonald, New Mill House, Elgin	165	None	5*s.*	Transactions, occasionally.
Essex Field Club, 1880	Essex F. C.	William Cole, Springfield, Epping New Road, Buckhurst Hill, Essex	300	None	15*s.*	'Essex Naturalist,' quarterly; 'Special Memoirs,' &c., occasionally.

CORRESPONDING SOCIETIES, &c. (*continued*).

Full Title and Date of Foundation	Abbreviated Title	Head-quarters or Name and Address of Secretary	No. of Members	Entrance Fee	Annual Subscription	Title and Frequency of Issue of Publications
Glasgow, Geological Society of, 1858	Glasgow Geol. Soc.	J. Barclay Murdoch, Capelrig, Newton-Mearns, Renfrewshire, and Peter Macnair	250	None	10*s.*	Transactions, annually.
Glasgow, Natural History Society of, 1851	Glasgow N. H. Soc.	Alex. Ross, 2 Kennyhill Gardens, Dennistoun, Glasgow	297	None	7*s.* 6*d.*	Transactions and Proceedings, annually.
Glasgow, Royal Philosophical Society of, 1802	Glasgow R. Phil. Soc.	Prof. Peter Bennett, 207 Bath Street, Glasgow	1,000	1*l.* 1*s.*	1*l.* 1*s.*	Proceedings, annually.
Halifax Scientific Society, 1874	Halifax S. S.	F. Barker, 11 Hall Street, Halifax	143	None	2*s.* 6*d.*	'Halifax Naturalist,' every two months.
Hampshire Field Club and Archæological Society, 1885	Hants F. C.	W. Dale, F.S.A., F.G.S., The Lawn, Archer's Road, Southampton	250	None	7*s.* 6*d.*	Proceedings, annually.
Haslemere Microscope and Natural History Society, 1888	Haslemere Mic. N. H. Soc.	Rev. G. B. Stallworthy, The Manse, Hindhead, Surrey	452	None	Minimum 2*s.*	Report, annually; Science Papers occasionally.
Hertfordshire Natural History Society and Field Club, 1875	Herts N. H. Soc.	A. E. Gibbs, F.L.S., St. Albans, and A. Sutton, Watford	160	10*s.*	10*s.*	Transactions, four times a year.
Holmesdale Natural History Club, 1857	Holmesdale N. H. C.	G. E. Frisby, 9 Fengates Road, Redhill	99	None	10*s.* and 5*s.*	Proceedings, every two or three years.
Hull Geological Society, 1887	Hull Geol. Soc.	J. W. Stather, F.G.S., 16 Louis Street, Hull	78	None	5*s.*	Transactions, annually.
Hull Scientific and Field Naturalists' Club, 1886	Hull Sci. F. N. C.	T. Sheppard, F.G.S., The Museum, Hull	180	None	5*s.*	Transactions, annually.
Institution of Mining Engineers, 1889	Inst. Min. Eng.	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne	3,100	None	None	Transactions, monthly.
Inverness Scientific Society and Field Club, 1875	Inverness Sci. Soc.	E. G. Critchley, 29 High Street, Inverness	189	None	5*s.*	Transactions, occasionally.
Ireland, Statistical and Social Inquiry Society of, 1847	Stat. Soc. Ireland	Dr. W. Lawson, Dr. N. M. Falkiner, and C. H. Oldham, 35 Molesworth Street, Dublin	100	None	1*l.*	Journal, annually.
Leeds Geological Association, 1873	Leeds Geol. Assoc.	E. Hawkesworth, Sunnyside, Crossgates, Leeds	80	None	5*s.*	Transactions, biennially.
Leeds Naturalists' Club and Scientific Association, 1868	Leeds Nat. C. Sci. Assoc.	J. M. Butler, 214 Tempest Road, Leeds	77	None	6*s.*	Transactions, occasionally.
Leicester Literary and Philosophical Society, 1835	Leicester Lit. Phil. Soc.	Corporation Museum. W. A. Evans, 24 Fosse Road South, Leicester	350 Membs. & Associates	None	Members 1*l.* 1*s.*; Associates 10*s.* 6*d.*	Transactions, half-yearly.
Liverpool Engineering Society, 1875	Liverpool E. Soc.	R. C. F. Annett, 4 Buckingham Avenue, Sefton Park, Liverpool	550	None	1*l.* 1*s.* and 10*s.* 6*d.*	Transactions and Report, annually.
Liverpool Geographical Society, 1891	Liverpool Geog. Soc.	Capt. E. C. Dubois Phillips, R.N., 14 Hargreave's Bldgs., Liverpool	650	None	Members 1*l.* 1*s.* Associates 10*s.* 6*d.*	Transactions and Report, annually.
Liverpool Geological Society, 1858	Liverpool Geol. Soc.	Royal Institution. W. A. Whitehead, B.Sc.	70	None	1*l.* 1*s.* and 10*s.* 6*d.*	Proceedings, annually.
London: City of London College Science Society	Lond. Coll. Sci. Soc.	City of London College, White Street, Moorfields, E.C. H. Norman Gray	80	None	5*s.*	Journal, monthly.
London: Quekett Microscopical Club, 1865	Quekett Club	A. Earland, 31 Denmark Street, Watford	382	None	10*s.*	Journal, half-yearly.
Manchester Geographical Society, 1884	Manch. Geog. Soc.	F. Zimmern and J. H. Reed, 16 St. Mary's Parsonage, Manchester	600	None	Members 1*l.* 1*s.*; Associates 10*s.* 6*d.*	Journal, quarterly; 'Geography,' monthly.
Manchester Geological and Mining Society, 1838	Manch. Geol. Min. Soc.	5 John Dalton Street, Manchester. William Saint	300	None	2*l.* 2*s.*, 1*l.* 5*s.*, and 1*l.*	Transactions, monthly.
Manchester Microscopical Society, 1880	Manch. Mic. Soc.	E. C. Stump, Malmesbury, Polefield, Blackley, Manchester.	214	5*s.*	6*s.*	Transactions and Report, annually.

Manchester Statistical Society, 1833	Manch. Stat. Soc.	Theodore Gregory, 3 York Street, Manchester	207	10s. 6d.	10s. 6d.	Transactions, annually.
Marlborough College Natural History Society, 1864	Marlb. Coll. N. H. Soc.	Marlborough College. E. Meyrick	280	1s. 6d.	3s. and 5s.	Report, annually.
Midland Counties Institution of Engineers, 1871	Mid. Count. Inst.	G. Alfred Lewis, M.A., Albert Street, Derby	420 Membs., Associates, & Students	1l. 1s. None	Members 31s. 6d.; Associates and Students 20s.	Transactions of Institution of Mining Engineers, monthly.
Midland Institute of Mining, Civil, and Mechanical Engineers, 1869	Midland Inst. Eng.	L. T. O'Shea, The University, Sheffield	306	None	1l. 10s.	Transactions of Inst. of Mining Engineers, monthly.
Norfolk and Norwich Naturalists' Society, 1869	Norf. Norw. Nat. Soc.	W. A. Nicholson, St. Helen's Square, Norwich	277	None	5s.	Transactions, annually.
North of England Institute of Mining and Mechanical Engineers, 1852	N. Eng. Inst.	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne	1,350	None	25s. and 42s.	Transactions of Inst. of Mining Engineers, monthly.
North Staffordshire Field Club	N. Staff. F. C.	W. Wells Bladen, Stone, Staffs	481	5s.	5s.	Report and Transactions, annually.
Northamptonshire Natural History Society and Field Club, 1876	Northants N. H. Soc.	H. N. Dixon, M.A., 23 East Park Parade, Northampton	210	None	10s.	Journal, quarterly.
Northumberland, Durham, and Newcastle-upon-Tyne, Natural History Society of	Northumb. N. H. Soc.	Hancock Museum, Newcastle-on-Tyne. N. H. Martin, F.L.S., and C. E. Robson	430	None	21s.	Transactions, annually.
Nottingham Naturalists' Society, 1852	Nott. Nat. Soc.	Prof. J. W Carr, M.A., University College, Nottingham	186	2s. 6d.	5s.	Report and Transactions, annually.
Paisley Philosophical Institution, 1808	Paisley Phil. Inst.	J. Gardner, 3 County Place, Paisley	630	5s.	7s. 6d.	Report, annually; Meteorological Obs., occasionally.
Perthshire Society of Natural Science, 1867	Perths. Soc. N. Sci.	Tay Street, Perth. S. T. Ellison	390	2s. 6d.	5s. 6d.	Transactions and Proceedings, annually.
Rochdale Literary and Scientific Society, 1878	Rochdale Lit. Sci. Soc.	J. Reginald Ashworth, D.Sc., 105 Freehold Street, Rochdale	253	None	6s.	Transactions, biennially.
Rochester Naturalists' Club, 1878	Rochester N. C.	John Hepworth, Linden House, Rochester	186	None	5s.	'Rochester Naturalist,' quarterly.
Somersetshire Archæological and Natural History Society, 1849	Som'setsh. A. N. H. Soc.	The Castle, Taunton. Lt.-Col. J. R. Bramble, Rev. F. W. Weaver, and C. Tite	642	10s. 6d.	10s. 6d.	Proceedings, annually.
South African Philosophical Society, 1877	S. African Phil. Soc.	G. M. Clark, South African Museum, Cape Town	207	None	2l.	Transactions, occasionally.
South-Eastern Union of Scientific Societies, 1896	S.-E. Union	Rev. R. Ashington Bullen, B.A., Pyrford Vicarage, Woking	43 Societies	None	Minimum 5s.	'South-Eastern Naturalist,' annually.
Southport Literary and Philosophical Society	Southport Lit. & Phil. Soc.	A. H. Garstang, 20 Roe Lane, Southport	151	None	5s.	Proceedings, annually.
South Staffordshire and East Worcestershire Institute of Mining Engineers, 1867	S. Staff. Inst. Eng.	Alexander Smith, M.Inst.C.E., 3 Newhall Street, Birmingham	192	1l. 1s. and 10s. 6d.	31s. 6d. and 21s.	Transactions of Institution of Mining Engineers, monthly.
Tyneside Geographical Society, 1887	Tyneside Geog. Soc.	Geographical Institute, St. Mary's Place, Newcastle-on-Tyne. Herbert Shaw, B.A., F.R.G.S.	1,000	None	10s.	Journal, annually.
Warwickshire Naturalists' and Archæologists' Field Club, 1854	Warw. N. A. F. C.	Museum, Warwick. O. West, Cross Cheaping, Coventry	81	2s. 6d.	5s.	Proceedings, annually.
Woolhope Naturalists' Field Club, 1851	Woolhope N. F. C.	Woolhope Club Room, Free Library, Hereford. H. Cecil Moore	250	10s.	10s.	Transactions, biennially.
Yorkshire Geological and Polytechnic Society, 1837	Yorks. Geol. Poly. Soc.	Rev. Wm. Lower Carter, M.A., F.G.S., Hopton, Mirfield	193	None	13s.	Proceedings, annually.
Yorkshire Naturalists' Union, 1861	Yorks. Nat. Union	The Museum, Hull. T. Sheppard, F.G.S.	406 and 2,700 Associates	None	10s. 6d.	Transactions, annually; 'The Naturalist,' monthly.
Yorkshire Philosophical Society, 1822	Yorks. Phil. Soc.	Museum, York. Dr. Tempest Anderson, C. E. Elmhirst, and Oxley Grabham, M.A.	400	None	2l.	Report, annually.

Catalogue of the more important Papers, and especially those referring to Local Scientific Investigations, published by the Corresponding Societies during the year ending May 31, 1905.

*** This Catalogue contains only the titles of papers published in the volumes or parts of the publications of the Corresponding Societies sent to the Secretary of the Committee in accordance with Rule 2.

Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

ALLEN, H. STANLEY. Experiments in Radio-Activity. 'Proc. Glasgow R. Phil. Soc.' XXXV. 82–96. 1904.

—— Notes on Physical Apparatus. 'Proc. Glasgow R. Phil. Soc.' XXXV. 176–180. 1904.

ASHWORTH, JAMES (N. Eng. Inst. Eng.). Observations on Water-sprayed or Damped Air in Coal Mines. 'Trans. Inst. Min. Eng.' XXIX. 11–21. 1905.

BARR, J. MILLER. Observations on Variable Stars. 'Proc. R. Astr. Soc. Canada, 1904,' 42–48. 1905.

BICKERTON, Prof. A. W. The Energy of Stellar Collision. 'Proc. R. Astr. Soc. Canada, 1904,' 57–61. 1905.

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Meteorological Observations on Ben Nevis.—Report of the Committee, consisting of Lord McLaren (*Chairman*), Professor A. Crum Brown (*Secretary*), Sir John Murray, Dr. Alexander Buchan, Professor Copeland, *and* Mr. R. T. Omond. (*Drawn up by* Dr. Buchan.)

The Committee was appointed, as in former years, for the purpose of co-operating with the Scottish Meteorological Society in making meteorological observations at the two Ben Nevis Observatories.

At the High Level Observatory Mr. Rankin and his assistants continued the eye-observations hourly, by day and night, for the first nine months of 1904. At the Low Level Observatory in Fort William the corresponding values were obtained from the self-recording instruments there for the same period. On October 1, 1904, both Observatories were closed, and the observations ceased.

The health of the observers continued good.

The Directors desire to very cordially thank the Rev. J. S. Begg and Messrs. H. R. Baxter, W. R. Bruce, and F. R. Lucas for their services as volunteer observers during the summer.

The principal results of the observations made at the two Observatories from January to September 1904 are detailed in Table I.

Table I.

1904	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
					Mean Pressure in Inches.								
Ben Nevis Observatory	25·086	24·870	25·293	25·124	25·303	25·470	25·463	25·405	25·464	—	—	—	—
Fort William	29·678	29·453	29·937	29·699	29·853	29·980	29·941	29·900	29·986	—	—	—	—
Differences .	4·592	4·583	4·644	4·575	4·550	4·510	4·478	4·495	4·522	—	—	—	—
					Mean Temperatures.								
Ben Nevis Observatory	25°·5	21°·8	23°·1	27°·7	32°·2	39°·5	43°·1	39°·4	38°·4	° —	° —	° —	° —
Fort William	41·2	37·8	39·5	45·3	48·9	55·0	57·6	55·2	53·3	—	—	—	—
Differences .	15·7	16·0	16·4	17·6	16·7	15·5	14·5	15·8	14·9	—	—	—	—
					Extremes of Temperature: Maxima.								
Ben Nevis Observatory	39·0	34·0	37·3	37·0	50·3	55·0	62·1	57·9	50·8	—	—	—	—
Fort William	51·4	48·0	51·1	58·0	73·1	74·4	75·5	73·0	67·5	—	—	—	—
Differences .	12·4	14·0	13·8	21·0	22·8	19·4	13·4	15·1	16·7	—	—	—	—
					Extremes of Temperature: Minima.								
Ben Nevis Observatory	15·5	10·5	10·1	19·6	18·0	27·6	32·1	30·5	30·0	—	—	—	—
Fort William	28·2	26·3	24·5	32·9	36·1	40·3	44·4	39·4	38·1	—	—	—	—
Differences .	12·7	15·8	14·4	13·3	18·1	12·7	12·3	8·9	8·1	—	—	—	—
					Rainfall in Inches.								
Ben Nevis Observatory	21·71	11·41	8·65	26·57	10·88	9·35	8·03	11·69	13·15	—	—	—	—
Fort William	8·04	6·14	4·87	10·26	6·51	4·97	5·30	7·12	8·63	—	—	—	—
Differences .	13·67	5·27	3·78	16·31	4·37	4·38	2·73	4·57	4·52	—	—	—	—
					Number of Days 1 in. or more fell.								
Ben Nevis Observatory	7	4	2	14	4	2	2	4	5	—	—	—	—
Fort William	0	2	0	2	1	1	1	2	3	—	—	—	—
Differences .	7	2	2	12	3	1	1	2	2	—	—	—	—

TABLE I.—*continued.*

1904	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
					Number of Days 0·01 *in. or more fell.*								
Ben Nevis Observatory	25	24	21	28	21	16	20	28	19	—	—	—	—
Fort William	27	20	17	26	23	14	21	26	19	—	—	—	—
Differences .	−2	4	4	2	−2	2	−1	2	0	—	—	—	—
					Mean Rainband (*Scale* 0–8).								
Ben Nevis Observatory	1·8	2·2	2·2	3·9	3·8	3·0	2·8	3·4	2·4	—	—	—	—
Fort William	3·6	4·0	3·8	4·4	4·4	4·9	4·9	4·7	4·2	—	—	—	—
Differences .	1·8	1·8	1·6	0·5	0·6	1·9	2·1	1·3	1·8	—	—	—	—
					Number of Hours of Bright Sunshine.								
Ben Nevis Observatory	9·2	22·6	69·6	18·5	80·2	187·3	140·4	37·4	101·5	—	—	—	—
Fort William	6·4	31·2	103·8	77·8	141·4	224·8	164·0	125·5	132·8	—	—	—	—
Differences .	+2·8	8·6	34·2	59·3	61·2	37·5	23·6	88·1	31·3	—	—	—	—
					Mean Hourly Velocity of Wind in Miles.								
Ben Nevis Observatory	18	19	16	17	14	10	11	8	11	—	—	—	—
					Percentage of Cloud.								
Ben Nevis Observatory	93	93	77	95	87	68	76	88	81	—	—	—	—
Fort William	85	84	68	82	78	63	76	80	71	—	—	—	—
Differences .	8	9	9	13	9	5	0	8	10	—	—	—	—

The above table shows for the first nine months of 1904 the mean monthly pressure; the mean and extreme temperatures; the amounts of rainfall; the number of days with rain, and of days with falls of 1 inch or over; the mean rainband; the hours of sunshine; the mean velocity in miles per hour of the wind at the top of the mountain, and the mean cloud amount. The mean barometric pressures at Fort William are reduced to 32° and sea-level, but those at Ben Nevis Observatory to 32° only.

The difference of the mean atmospheric pressures at the two Observatories ranged from 4·644 inches in March to 4·478 inches in July. At the top the absolutely highest pressure during the period was 25·925 inches at 10 P.M. on January 21, and at Fort William 30·658 inches at midnight on the same day. The lowest pressures occurred at 1 P.M. on February 13, being respectively 24·017 inches and 28·419 inches. Thus the difference of the extremes at top and bottom were 1·908 inch and 2·239 inches respectively. The low mean pressures for February are noteworthy, that at Fort William being as much as four-tenths of an inch below the mean for thirteen years, and that at the top almost the lowest February mean in twenty-one years, February 1885, with a mean of 24·858 inches, alone being lower.

The deviations of the mean temperatures of the months from the averages of the thirteen-year period 1891–1903, are shown in Table II.:—

TABLE II.

	Fort William.	Top of Ben Nevis.		Fort William.	Top of Ben Nevis.
	°	°		°	°
January	+2·5	+2·1	June	−0·4	−0·5
February	−1·0	−2·3	July. . . .	+0·5	+1·4
March	−0·9	−1·2	August . . .	−1·3	−1·4
April	+0·2	−0·6	September . .	+0·1	+0·4
May.	−0·8	−1·0			

January was a somewhat mild month, with the highest mean temperature since 1898, and both February and March were, at both Observatories, colder than January. On the whole, however, the deviations of temperature from the normal were in no way remarkable. The absolutely highest temperature during the period at Fort William was 75°·5 on July 11 and 12, and on Ben Nevis 62°·1 on the former day, the lowest at Fort William being 24°·5 on March 15, and on Ben Nevis 10°·1 on March 1.

In Table III. are given for each month the lowest observed hygrometric readings at the top of Ben Nevis (reduced by means of Glaisher's tables) :—

TABLE III.

1904	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Dry Bulb	20°·5	22°·2	26°·8	30°·3	31°·0	49°·5	55°·8	51°·1	44°·6	° —	° —	° —
Wet Bulb	17·4	18·0	20·7	25·3	24·0	38·0	40·3	44·2	31·1	—	—	—
Dew-point	–4·3	–9·3	–8·0	10·3	5·1	25·7	26·3	37·0	14·9	—	—	—
Elastic Force	·035	·027	·029	·069	·054	·139	·143	·220	·085	—	—	—
Relative Humidity [Sat.=100]	32	23	20	41	31	39	32	59	29	—	—	—
Day of Month	31	17	24	19	20	7	10	30	23	—	—	—
Hour of Day	24	14	23	4	7	9	14	2	22	—	—	—

Of these relative humidities the lowest, 20 per cent., occurred on March 24 at 11 P.M. The air on the summit had been very dry for several hours, but at midnight on the same day, or only one hour after the minimum humidity for the period had been recorded, complete saturation set in, an excellent example of the rapid changes of humidity so frequently observed on Ben Nevis. This sudden variation was not due to any change of wind direction, but to fog rising from the valleys and enveloping the mountain top. The longest spells of complete saturation were from January 8 to 22, and from 9 A.M. on March 31 to 8 P.M. on April 14.

The rainfall for the nine months at the top was 121·44 inches, or 10·51 inches above the mean of nineteen years; whilst the aggregate at Fort William was 61·84 inches, or 9·02 inches above the average for the same period. At both stations the amounts for April were much the largest recorded during twenty years, the rainfall at the top being more than thrice the normal. In that month there were on Ben Nevis twenty-eight rainy days, of which three had falls exceeding 2 inches, and no fewer than fourteen falls of more than an inch, the aggregate for the first ten days of the month being as much as 17·10 inches. At the summit station the greatest fall recorded in a single day was 2·69 inches on January 14, the corresponding fall at the base being 0·65 inch, whilst the maximum daily amount at Fort William was 2·07 inches on September 5, the fall on Ben Nevis on that day being 2·08 inches, or practically the same.

At the top of Ben Nevis the number of rainy days during the period was 202, or ten above the average, and at Fort William 193, or seventeen above the average. The number of rainy days in April and August was unusually large, and it may be noted that in January, May, and July there were more rainy days at the base of the mountain than on the top. The number of days with falls of 1 inch or over was, on Ben Nevis forty-four, or nine above the average, and at Fort William twelve, or two above the average.

The sunshine recorder on Ben Nevis for the nine months registered 666 hours, or eighteen hours above the average of twenty years, whilst at Fort William the aggregate was 1,008 hours, or four hours more than the average of thirteen years. At both stations sunshine was very deficient in April and May, the former month having the smallest total on record. On the other hand, June, July, and September had amounts much above the average.

The estimated cloud amounts compare in a satisfactory manner with the records of sunshine, the value being, for example, very high in April and low in June.

Auroras were observed on January 23, February 8, May 6.

St. Elmo's Fire :—January 7, 14, 27 ; March 22 ; May 3, 17 ; June 20.

Zodiacal Light :—March 9, 10.

Thunder and Lightning :—February 12 ; May 1 ; July 31.

Thunder only :—July 13 ; August 14.

Lightning only :—January 10, 23, 28.

Solar Halos :—February 1, 9 ; March 10 ; April 18 ; May 20 ; June 2, 12 ; September 2.

Lunar Halos :—February 28 ; March 1 ; August 25.

Meteorological observations on Ben Nevis having now ceased, the object for which this Committee was appointed no longer exists. The Directors of the Observatories, however, have still a large and costly work before them. The double record of the High and Low Level Observations, the unique character of which has been pointed out in previous Reports of the Committee, has still to be discussed in its relations to weather, and especially to those movements of the areas of high and low barometric pressure on which changes of weather mainly depend. The scientific and climatological discussion, so far as already carried out in respect to areas of high and low pressure, clearly indicates the importance of this double record in supplying data for the investigation of the causes of weather changes.

The closure of the Observatories prevents their observations being made use of directly for weather forecasting, but the Committee confidently expects that the results of the discussion mentioned above will supply forecasters with new information in respect to changes of weather, and thus materially aid this important branch of practical meteorology.

Magnetic Observations at Falmouth Observatory.—Report of the Committee, consisting of Sir W. H. PREECE (*Chairman*), Dr. R. T. GLAZEBROOK (*Secretary*), Professor W. G. ADAMS, Captain CREAK, Mr. W. L. FOX, Principal Sir ARTHUR RÜCKER, *and* Professor A. SCHUSTER, *appointed to co-operate with the Committee of the Falmouth Observatory in their Magnetic Observations.*

THE grant voted by the Association last year has been expended in carrying on the magnetic observations at Falmouth Observatory.

The results of the observations during 1904 have been published in the Annual Report of the National Physical Laboratory, and are very satisfactory. The vertical force curves have been measured for the first time, and the results for 1903 and 1904 are given in the Report.

In connection with this work Mr. Kitto spent some time at Kew during the early part of the year.

Dr. Chree has published 'An Analysis of the Results of the Falmouth Magnetographs on Quiet Days during the twelve years 1891 to 1902' in the 'Transactions' of the Royal Society for 1904; this contains a number of interesting results, which confirm in a remarkable manner the consequences deduced from his earlier paper dealing with the Kew curves.

The Committee regret to learn that the difficulty of the situation has caused great delay in the building of the new Observatory at Eskdale Muir, which, they are informed, cannot be ready until the end of 1906. In view of the importance of maintaining continuity of the magnetic records, they ask for reappointment, with a grant of 50*l*.

Investigation of the Upper Atmosphere by Means of Kites in co-operation with a Committee of the Royal Meteorological Society.—Fourth Report of the Committee, consisting of Dr. W. N. SHAW (*Chairman*), Mr. W. H. DINES (*Secretary*), Mr. D. ARCHIBALD, Mr. C. VERNON BOYS, Dr. A. BUCHAN, Dr. R. T. GLAZEBROOK, Dr. H. R. MILL, Professor A. SCHUSTER, *and* Dr. W. WATSON.

THIS Committee acts jointly with a Committee of the Royal Meteorological Society.

Since the last report a brief account of the observations obtained from H.M.S. 'Seahorse' has been published in the 'Quarterly Journal of the Royal Meteorological Society,' but the results have not yet been fully worked up.

Apparatus for testing and calibrating the meteorographs has been made by Mr. J. J. Hicks, and consists of an ordinary air-pump with a large receiver. Inside the receiver there is a coil of metal tube, through which warm water or a freezing-mixture can be circulated; there is also a small electric fan to ensure uniformity of temperature throughout the enclosed space. The meteorograph is placed inside, and the pressure and temperature altered in any desired way. A record is kept, and is compared with the trace obtained from the meteorograph when it is taken out of the receiver. Inasmuch as the thermal capacity of the heavy glass receiver and metal plate is very considerable, the process of warming or cooling the interior is a slow one. A few tests have been made for ascertaining the extent to which the temperature correction of the barograph is dependent on the pressure, but generally a quicker plan is employed for testing the thermograph. The instrument is placed in a thin metal case with a water-jacket. The lid is also jacketed, and by circulating a liquid through the jacket, and enclosing the whole arrangement in felt or other non-conducting material, there is no difficulty about rapidly bringing the meteorograph to any desired temperature.

The pen of the hygrograph moves in accordance with the change of length of 4 feet of human hair. The approximate scale is a change of length of ·45 inch from absolute dryness to complete saturation, but a more exact determination is now being made by hanging a small weight at the end of 4 feet of hair in the open, and taking simultaneous readings of its length and of a wet and dry bulb thermometer.

Continuance of Observations.

The apparatus used on board the 'Seahorse' was fitted up at Oxshott at the end of September 1904, and since that date forty-five ascents, giving good records, with an average height of about 4,400 feet, have been made. These include most of the days appointed by the President of the International Aëronautical Commission. The observations for those days are regularly reported to Professor Hergesell, and will appear in the publications of the International Committee.

Kite Ascents at Oxshott.

—	Length of Wire	Maximum Height	Temperature Decrease (Degrees Fahr.)	Number of Kites
1904.				
Sept. 30	8,000	5,000	*10	1
Oct. 3	6,200	3,500	14	1
,, 5	8,240	4,650	*10	1
,, 6	7,300	4,250	17	1
,, 7	8,000	5,400	16	1
,, 8	4,800	3,250	12	1
Nov. 3	6,100	3,250	4	1
,, 8	4,560	3,000	13	1
,, 30	7,180	3,800	12	1
Dec. 1	6,700	3,200	*7	1
,, 5	6,200	3,850	16	1
,, 13	6,400	3,280	9	1
,, 16	3,600	2,850	9	1
,, 19	6,100	3,250	13	1
,, 29	9,560	4,400	10	1
1905.				
Jan. 4	8,000	5,500	17	1
,, 5	10,500	5,800	17	1
,, 28	6,300	3,600	*−6	1
,, 30	5,500	2,700	15	1
Feb. 3	6,000	3,350	11	1
Feb. 4	3,100	2,600	8	1
,, 10	11,600	7,900	*15	2
,, 17	7,300	4,250	16	1
,, 18	8,000	5,200	*5	1
Mar. 2	6,500	4,650	14	1
,, 3	4,200	3,170	11	1
,, 6	5,400	4,600	12	1
,, 8	6,000	4,100	13	1
,, 17	5,100	3,300	12	1
,, 25	4,500	2,880	10	1
,, 28	7,000	4,400	15	1
,, 29	8,000	5,600	17	2
,, 31	10,000	6,500	26	2
Apr. 1	8,000	4,900	13	2
,, 4	9,000	5,470	19	2
,, 7	9,000	6,200	15	2
,, 13	8,000	5,050	21	1
,, 17	5,700	4,000	6	1
,, 24	5,100	3,800	11	1
,, 25	12,000	7,600	20	2
,, 27	10,000	6,000	12	2
,, 28	5,000	3,500	10	1
May 5	10,300	7,000	15	2
,, 8	6,700	4,300	22	2
June 1	12,000	7,300	31	2

* Indicates a temperature inversion.

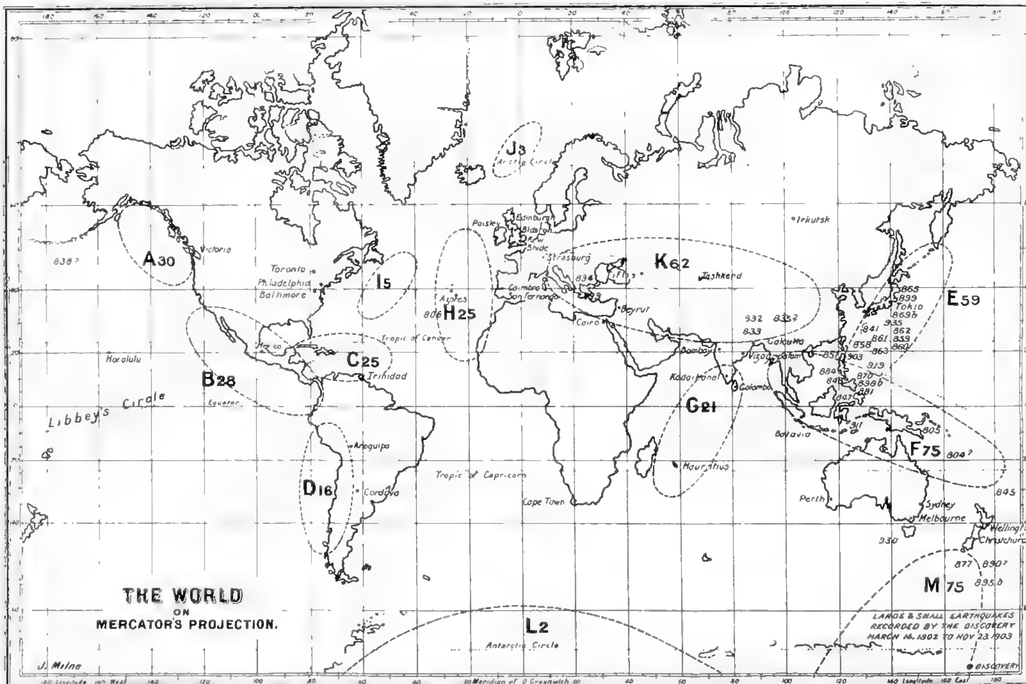
Observations on the 'Helga.'

The observations which it was hoped would be made on the s.s. 'Helga' have fallen through, owing to the increased duties devolving upon the officers and men of that vessel.

Funds.

Since the last report a sum of 85*l.* 10*s.* 8*d.* has been expended on the investigation. This includes 22*l.* for a testing apparatus, and 12*l.* for a corrugated iron shed (20 × 10 × 10 feet) in which to store the kites without taking them to pieces, both of which will be of permanent use. The remaining fifty odd pounds have been spent on new kites and meteorographs and on making good the ordinary wear and tear of the outfit.

Earthquake districts are indicated A, B, C, &c., and the number of earthquakes which since 1899 have originated from these is expressed in large numerals. Origins for 1904 are indicated by their B.A. Shide Register number. Observing stations are named.



Illustrating the Report on Seismological Investigation.

Apparatus.

Comparatively little trouble has been experienced during the winter with any part of the apparatus. The steam engine that was bought last year did not prove satisfactory while in use on the 'Seahorse,' but has been altered. The wire that was wound on the reel at Crinan is still in use without a join, although, of course, pieces have occasionally been lost from the end. The chief requirement is a satisfactory kite, which will combine the three characteristics of flying at a good angle, of being stable and not liable to damage in any wind, and of never exerting an excessive pull. Perhaps such a kite can never be obtained, but there are such an infinite number of ways in which the various types of kite now in use may be altered—and the most trifling alterations of detail are sometimes capable of producing very great effects—that extensive experimental work can hardly fail to develop a kite better than any at present available.

Observations are being continued at Oxshott, but it is not proposed to make any attempt to obtain a vessel for work elsewhere this summer. The Committee ask for reappointment without a grant.

Seismological Investigations.—Tenth Report of the Committee, consisting of Professor J. W. JUDD (*Chairman*), Mr. J. MILNE (*Secretary*), Lord KELVIN, Professor T. G. BONNEY, Mr. C. V. BOYS, Professor G. H. DARWIN, Mr. HORACE DARWIN, Major L. DARWIN, Professor J. A. EWING, Dr. R. T. GLAZEBROOK, Mr. M. H. GRAY, Professor C. G. KNOTT, Professor R. MELDOLA, Mr. R. D. OLDHAM, Professor J. PERRY, Mr. W. E. PLUMMER, Professor J. H. POYNTING, Mr. CLEMENT REID, Mr. NELSON RICHARDSON, *and* Professor H. H. TURNER. (*Drawn up by the Secretary.*)

[PLATE I.]

CONTENTS.

I. *General Notes on Stations and Registers.*

THE registers issued during the past year are Circulars Nos. 10 and 11. They refer to Shide, Kew, Bidston, Edinburgh, Paisley, Toronto, Victoria (B.C.), San Fernando (Spain), Ponta Delgada (Azores), Cape of Good Hope, Alipore, Bombay, Kodaikânal, Batavia, Perth, Trinidad, Christchurch, Cairo, Cordova (Argentina), Irkutsk, Baltimore and Beirût.

Records obtained by means of horizontal pendulums (Milne type) at Irkutsk, Tiflis and Tashkent are published in the 'Bulletin de la Commission Centrale Sismique Permanente' of St. Petersburg, whilst references to similar records made in Strassburg are to be found in the 'Monatsbericht der Kaiserlichen Haupstation für Erdbebenforschung

zu Strassburg, i/E.' These latter records only indicate whether the instrument had responded to certain disturbances, and do not furnish information as to times and amplitudes.

It is anticipated that continuations of registers from Mauritius, Tokyo, and Wellington will shortly be received.

From the United States Coast and Geodetic Survey your Secretary learns that copies of registers are to be forwarded from Honolulu, while Professor H. F. Reid writes to the effect that Professor S. J. Cunningham will recommence observations at Strathmore College, Philadelphia.

Four other observatories, the records from which would be of great value, particularly as an assistance in localising seismic foci, are Mexico, Arequipa, Melbourne, and Sydney. The registers from the latter two, taken in conjunction with those from New Zealand and those obtained by the 'Discovery,' the examination of which has been entrusted to your Secretary, will undoubtedly throw light upon suboceanic changes now in progress in the Antarctic regions.

II. *The Situation of Stations.*

As it is recognised that the character of a seismogram is to a greater or less extent dependent upon the topographical and geological situation of the observatory at which it was obtained, a letter was sent to each of the stations at which horizontal Milne pendulums have been established, asking for information relating to their installations. The replies which have been received run as follows :—

Abbasia. Cairo, Egypt. (*See also Helwan.*)

Lat., 30° 04′ 36″ N.; long., 31° 17′ 13·5″ E.; alt., 33 metres.

Foundation is on sandy loam.

Topographical Situation.—On the border between desert and cultivated delta; 5 kilometres from the Nile.

Geological Structure.—The neighbouring desert to the east is mainly horizontally bedded limestone. The actual surroundings are Nile valley deposits.

The station is at an astronomical observatory.

B. H. WADE, Superintendent.

Azores. Ponta Delgada, S. Miguel, Azores (*Meteorological Observatory*).

Lat., 37° 44′ 18·3″; long., W.G. 25° 41′ 15″ (1h. 42m. 45s.); alt., 16 metres.

Foundation is on a layer of basaltic rock.

Topographical Situation.—On low ground with an extent of nearly 2 kilometres. To the south (nearly 120 metres) is the sea. The hills (small or great craters) near the town have a mean altitude of 180 metres. The nearest is situated at a distance of 2 kilometres. The great mountains lie to the N.E. and E. Their height is 900 metres, and they are 9 and 12 kilometres from the town.

Geological Structure.—A very thin soil of volcanic cinders, covering a layer, very thick (unknown thickness), of basaltic rock. The layer was produced by the descent to the sea of a lava stream poured from a crater situated at the north of the town of Ponta Delgada.

Time-keeping.—The hour of the watch is every day compared with the regulator established in the Observatory.

FRANCISCO A. CHAVES,
Director of the Meteorological Service of the Azores.

Baltimore, Md., U.S.A.

Lat., 39° 17′ 8″ N.; long., 76° 37′ 25″ W.; alt., 100 feet.

Foundation is on brick pier, built nearly thirty years ago, on sands and clays.

Topographical Situation.—On a hilly plateau.

Geological Structure.—Sands and clays, about 60 feet thick at this point, rest on an irregular surface of crystalline rock dipping toward the south-east. The water-level is about 50 feet from the surface.

Time-keeping.—My clock is checked weekly by means of a sidereal clock. My clock does not keep very good time.

HARRY FIELDING REID.

Batavia. Royal Magnetical and Meteorological Observatory.

Lat., 6° 11′ 0″ S.; long., 7h. 7m. 19s. E.; alt., 8 M.

Foundation is on brick pillar.

Topographical Situation.—Flat country.

Geological Structure.—Alluvium.[1]

Time-keeping.—An electrical signal is given hourly by an observer from the astronomical clock, controlled monthly by observation of the sun.

Dr. S. FIGEE, Director.

Beirût Protestant College, Syria.

Lat., 33° 54′ 20″ N.; long., 35° 28′ 10″ E.; alt., 105 feet.

Foundation is on solid rock.

Topographical Situation.—The general trend of the coast ridge, which has an altitude of 2,000 feet, is N.N.E.–S.S.W. At Beirût a limestone spur juts out about five miles due west. It was, doubtless, once an island. It is now joined with the mainland by a narrow alluvial plain, and the space to the south is filled in by a late formation derived from shifting sand. Along the northern face of this spur there is a ledge, averaging 100 yards wide, about 10 feet above sea-level; then a sudden rise to a terrace 100–140 feet above sea, with a further rise to the highest part of the ridge, 500 yards back, the height of which is 225–300 feet. The Observatory is at the very edge of the middle plateau, about 400 yards from its western extremity, and is about 100 yards south of the seashore, which is rocky. Six miles to the east the first ridges of Lebanon rise to an altitude of 2,500 feet, with the main ridge, 15–20 miles further, rising to 5,000–8,700 feet.

Geological Structure.—Stratified limestone (tertiary), of unknown thickness, but probably not less than 500 feet, and probably with underlying sandstone 100–400 feet thick, under which is limestone. Water-bearing strata at sea-level. Dip of strata, 5° N.–S.

The station is at an astronomical observatory.

ROBERT H. WEST.

Bidston (Liverpool Observatory), England.

Lat., 53° 24′ 5″ N.; long., 3° 4′ 20″ W.; alt., 202 feet (barometer cistern). The foundation of seismometer is at an altitude of 178 feet.

Foundation is on sandstone.

Topographical Situation.—On the top of a small eminence, from which the ground slopes away rapidly in every direction but the south. It is the highest ground in the immediate neighbourhood.

Geological Structure.—The rocks at Bidston are strongly current bedded, hence dips are not very reliable. The general dip is to the east, about 5°. Under the Observatory there are 25 feet of Keuper basement beds, then a thin band of marl less than a foot in thickness, followed by Upper and Lower Bunter. In a boring near Bidston station the Bunter has been proved to be 2,850 feet below surface. This may include some Permian. The line of water saturation varies, as it is affected by pumping. It is probably at a depth of 200 feet.

The station is an astronomical observatory.

WILLIAM E. PLUMMER.

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[1] Also see *Brit. Assoc. Rep.*, 1899, p. 178.

Colaba, Bombay.[1]

Lat., 18° 53′ 45″ N.; long., 72° 48′ 56″ E.; alt., about 35 feet above sea-level.

Foundation is on rock—a large boulder.

Topographical Situation.—The Observatory is located at almost the extremity of a narrow and somewhat rising strip of land called Colaba, about two and a half miles in length, running into the sea almost S.S.W. from the island of Bombay. The breadth of the strip where the Observatory is situated is about 500 yards, about 200 yards of which, near the eastern side, being occupied by the Observatory compound. The main Observatory buildings are located on the top of a small mound, sloping somewhat more abruptly on the east than on the west. The mean level of the ground on which all observation buildings are located is about 32 feet above mean sea-level.

Geological Features.—The rocks generally in the vicinity and of the neighbouring hills, such as the Malabar and Cumballa Hills, are basaltic traps and are highly magnetic. The probable dip of the trap is about 5° to the westward. Excavations show here and there large boulders of basalts lying in thick and hard beds of red and somewhat sandy soil. At several places where the rock crops out through the soil the depth of basalts appears to be very great, continuous rock being met to a considerable depth, as shown by the sides of an existing deep well in the compound. Water is always available at a depth of about 30 feet below ground. The nearest hill is Malabar Hill, about four miles north, across the Back Bay, while the highest hill, the Karauja Hill, about eight miles across the harbour towards E.S.E., subtends an angle of about 1° as seen from the Observatory.

This is an astronomical observatory.

N. A. F. MOOS, Director.

Calcutta (Alipore Observatory), India.[2]

Cape of Good Hope, Royal Observatory.

Lat., 33° 56′ 3″·6; long., 1h. 13m. 54.76s. E.; alt., 33 feet.

Foundation is on the partly weathered rock of the Malmesbury beds—a quartzose slate—with good unweathered rock at from 16 to 30 feet below.

Topographical Situation.—In a cellar of the main Observatory building, which is situated on a rising ground on the comparatively level country between Table Bay and False Bay.

Geological Structure.—'The site is underlain by the oldest rocks of this part of South Africa, the slates and quartzites known as the Malmesbury beds. These rocks form the whole S.W. corner of the Cape Colony, and extend over many hundred square miles of country. No fossils have been discovered in any of the outcrops, but there is no doubt that the old slates and quartzites were deposited at some period long anterior to the Devonian rocks of Europe. The Bokkevelt beds of Cape Colony contain Devonian fossils. Between these beds and the tilted Malmesbury slates there are 4,000 to 5,000 feet of Table Mountain sandstone, which is itself separated by a very marked unconformity from the old slate series. The Malmesbury beds in petrological character resemble some of the Silurian slates and grits of the southern uplands of Scotland. "Cleaved quartzite" is the most accurate description.'—*Dr. Corstorphine's Report.*

DAVID GILL, H.M. Astronomer.

Carisbrooke (Newport, Isle of Wight), England.

Observations at this station have been discontinued. Its situation is described in the 'British Association Reports' for 1896, p. 185.

[1] See *Brit. Assoc. Rep.*, 1899, p. 176. [2] *Ibid.*, 1899, p. 177.

Coimbra (Observatorio Magnetico-Meteorologico), Portugal.

Lat., 40° 12′ N.; long., 8° 25′ W., Green.; alt., 141 metres.

Foundation is on rock. The pier is a cut limestone, erected on a base of masonry, which rests on a 25 cm. layer of concrete, spread on the rock.

Topographical Situation—On a hill-top. The height above the surrounding country is about 100 metres from the south side and 15 metres from the north. The slopes are gentle from all sides.

Geological Structure.—The nature of the rock is generally Old Red Sandstone. Depth of water-bearing strata undetermined.

Time-keeping.—The time-keeping is secured by transits of stars, frequently observed in the adjoining Observatory. The watch of the seismograph is compared every day with a mean-time chronometer, whose corrections are carefully determined.

DR. A. S. VIÉGAS, Director.

Edinburgh Royal Observatory, Edinburgh, Scotland.

Lat., 55° 55′·5 N.; long., 3° 11′ 3″ W.; alt., 441 feet.

Foundation is on granite pier, 3 feet high and 18 inches square, built on the surface of the rock, 431 feet above sea-level. A brass plate is placed under each of the levelling screws.

Topographical Situation.—The Observatory, in the basement of which the instrument is placed, is situated on the ridge of the Blackford Hill, sloping upwards to the west, 1 in 10, to a height of about 520 feet above sea-level, and downwards towards the east, about 1 in 12, to the 300 feet contour line. Towards the north the hill slopes downwards, at first 1 in 7, afterwards less steeply, to about the 200 feet contour line, where it reaches the general level of the neighbourhood. Towards the south the decline is less rapid, being practically level for some 300 yards, after which it slopes to the top of a cliff, about 80 to 100 feet high, overhanging the Braid Burn.

Geological Structure.—'Blackford Hill is practically one great mass of andesite lava (of Devonian age). There is a very thin band of tuff, which is a few hundred feet below the surface of the rock upon which the Observatory stands, but it is only 2 feet in thickness, and it is almost as compact as the lava above it and below. The chief disturbing factor, so far as the andesite lava is concerned, is the shattered condition of the rock, arising from the joints and divisional planes which traverse it in many directions. But deep within the hill I think that these are almost negligible.'

THOMAS HEATH.

Helwan Observatory, Cairo, Egypt. (See also Abbasia.)

Lat., 29° 51′ 34″ N.; long., 31° 20′ 30″ E.; alt., 115 metres above sea.

Foundation is on Eocene limestone rock.

Topographical Situation.—The Observatory is situated on a spur of the eastern desert plateau, which is cut up by numerous 'wadies,' or dry valleys. The spur, which rises some 55 metres above the level of Helwan town, is about 80 metres in width, with a flat top and a valley on either side.

Geological Structure.—Horizontally bedded Eocene limestone, mostly of a rather chalky nature, in thick beds, with occasional siliceous and marly bands. Comparatively little vertical jointing is seen in the rock, but the horizontal bedding-planes are well marked. Water-bearing beds do not occur higher than 60 metres below the site.

The station is an astronomical observatory.

B. H. WADE, Superintendent.

Honolulu Magnetic Observatory (U.S. C. and G. Survey).

Lat., 21° 19′·2 N.; long., 158° 03′·8 W.; alt., 45 feet.

Foundation is on a concrete pier on solid coral limestone.

Topographical Situation.—The Observatory is located on the large, level coral

plain which forms the south-western part of Oahu Island, west of Pearl Harbour. This plain is about nine miles in length, and of an average width of about two and a half miles, and is practically level. The Waianæ mountains rise to the west of north, the first high summit being $5\frac{1}{2}$ miles distant N., 30° W., 2,450 feet; the second, $6\frac{1}{2}$ miles N., 22° W., 2,740 feet; the third, $7\frac{1}{4}$ miles, N. 20° W., 3,110 feet. The Observatory is about one mile from the seashore.

Geological Structure.—The coral plain is a raised barrier reef of great depth, estimated at 2,500 feet at the seashore. On the basis of this estimate the depth at the Observatory would be about 1,800 feet. The surface is covered with loose coral stones of all sizes, with very little soil, and there are frequent large, irregular holes, 10 or 15 feet deep (some reaching a depth of even 30 feet or more). Water is found at a depth of about 45 feet, or about sea-level.[1]

Time-keeping.—Star observations with theodolite.

S. A. DEEL, Magnetic Observer U.S. C. and G. S.

Kodaikânal Observatory, Madras, India.

Lat., 10° 13′ 50″; long., 5h. 09m. 52s. E.; alt., 7,688 feet.

Foundation is on rock.

Topographical Situation.—On the top of a hill. At a distance of about two miles on the east and south sides the hills slope very steeply down to a height of 800 to 900 feet above sea-level. Towards the west and north the plateau is much more extensive. The highest point lies to the W.S.W., is four miles distant, and the top is 8,200 feet. The Palani Hills, on which Kodaikânal stands, form a mass fifty-four miles long from east to west and fifteen miles broad. The plateau is at an average elevation of 7,300 feet above sea-level.

Geological Structure.—'Charnockite,' 'a group of hypersthene-bearing rocks, which form the largest single section of the Archæan gneisses in peninsular India.'[2] The rocks have been but little disturbed, and there are well-marked lines of false bedding running N.E. and S.W. The chief precipices face either nearly south or nearly east, so the chief lines of jointing may be considered parallel to these directions.

It is an astronomical observatory, but it also receives a direct signal from the Madras Observatory clock at 4 P.M. daily.[3]

C. MICHIE SMITH, Director Kodaikânal and Madras Observatories.

Royal Alfred Observatory, Mauritius.

Lat., 20° 5′ 39″ S.; long., 3h. 50m. 12·6s. E. of Greenwich; alt., 178 feet.

Foundation is on alluvium.

Topographical Situation.—On a plain three miles from the west coast. From N. through E. to S.E. the ground generally rises to Mount Pitou, the summit of which bears about E.S.E., and is 917 feet above mean sea-level. Between S.E. and S.W. there is a chain of mountains, the highest peak of which, the Pieterboth, bears nearly six miles due south and has an altitude of 2,874 feet.

Geological Structure.—The island is of volcanic origin. It has been supposed that the alluvium has a depth of from 2 to 14 feet, below which is solid basalt; but I have recently dug 23 feet, to obtain a solid rock foundation for the seismograph, and instead of rock I came to water, which has risen 9 feet in the hole. This will account for the large changes of level produced by heavy rains. I have also recently discovered that a lamp at night (to check tremors) introduces a change of level, the boom tilting away from the lamp. It seems as if the tremors were caused by radiation of heat from the pier, and I thought our magnetic basement (whose floor is 13 feet below the surface of the ground, and in which the diurnal range of temperature is usually less than 0·3° F.) would be an ideal place for the seismograph. There is only one spot where there is sufficient room for the instrument, and in that spot, as I have said, we came to water at $10\frac{1}{2}$ feet, *i.e.*, $23\frac{1}{2}$ feet below the surface.

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[1] See *Brit. Assoc. Rep.*, 1903, p. 78.

[2] Holland, *Memoirs of the Geological Survey of India*, vol. xxviii.

[3] Also see *Brit. Assoc. Rep.*, 1899, p. 175.

I hope to be able to try another spot shortly, below the floor of the main building.

Time-keeping.—By the usual methods at an astronomical observatory.[1]

T. F. CLAXTON, Director.

Paisley (The Coats Observatory), Scotland.

Lat., 55° 50′ 44″ N.; long., 0h. 17m. 43·3s. W.; alt., 100 feet above sea-level.

Foundation is on boulder clay.

Topographical Situation.—Instrument is placed near the top (but on the south side) of Oakshaw Hill, the most northerly of a series of ridges which run east and west between the Gleniffer Braes (800 feet high and three miles to the south) and the Clyde, a tidal river, three miles to the north.

Geological Structure.—Alluvium, *i.e.*, boulder clay, which may be 30 feet thick, resting probably on limestone or sandstone. The district is, geologically, a very troubled one; *e.g.*, the surface of Paisley town—say, a mile square—showing moss, running sand, shell clay, boulder clay, limestone, sandstone, coal, dolerite, &c.

The station is an astronomical observatory.

DAVID CRILLEY, Superintendent.

Kew Observatory (National Physical Laboratory), England.

Lat., 51° 28′ N.; long., 0° 19′ W.; alt. of seismograph, 20 feet above M.S.L.

The instrument's foundation is on pipes filled with cement, resting on a thick bed of cement. The ground immediately below, consisting of earth and brick rubbish, was rammed hard before the cement was laid. The supports are isolated from the paving-stone of which the flooring is composed.

Topographical Situation.—The Observatory stands on a low mound, presumably artificial. It has a deep basement, in which the seismograph is situated, the whole surrounded by unused subterranean cellars. The surrounding ground is nearly level and covered with grass, except a small garden. The Old Deer Park, in which the Observatory stands, is bounded on its west and north by the Thames, whose nearest approach to the building is some 300 yards. In exceptional floods and high tides water sometimes spreads to within fifty or sixty yards of the Observatory, and has once or twice reached the basement. The nearest ground showing any considerable slope is Richmond Hill. The upward slope of the hill commences about 1,500 yards away in a south-eastern direction. Its altitude is only some 200 feet, the highest point being some two miles distant.

Geological Structure.—We have no special knowledge. No deep boring has been made nearer than that of the Richmond Water Company. The soil of the immediately adjacent park is alluvium (there are patches of sand and gravel not very far off). This we suppose to rest on the London Clay at no great depth.

Time-keeping.—A daily Greenwich time-signal is received, and there are good clocks.

CHARLES CHREE, Superintendent.

Perth Observatory, Western Australia.

Lat., 31° 57′ 07″·4 S.; long., 7h. 43m. 21·74s. E.; alt., 200 feet.

Foundation is on sand.

Topographical Situation.—Hilltop. Level for half a mile south, then drops suddenly to sea-level. Gradual slope downwards in other directions, though steep to east.

Geological Structure.—Considerable depth of sand (may be 100 feet or more) on top of limestone.

W. ERNEST COOKE, Government Astronomer.

San Fernando (Observatorio de Marina), Cadiz, Spain.

Lat., 36° 27′ 42″; long., 0h. 24m. 49·34s. W.G.; alt., 28·5 metres.

Foundation is on rock.

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[1] See *Brit. Assoc. Rep.*, 1899, p. 179.

Topographical Situation.—The Observatory is situated on a hilltop, whose height above the environs is 10 metres. The dip (mean) is 7°.

Geological Structure.—The instrument is mounted on a pillar built on the same rock, which is a calcareous one, whose thickness is very variable.[1]

The station is an astronomical observatory.

CAPITAN DE FRAGATA TOMAS DE AZCARATE, Director.

Shide, Newport, Isle of Wight, England.

Lat., 50° 41′ 18″ N.; long., 1° 17′ 10″ W.; alt., about 50 feet.

Foundation is on a brick column, 18 inches square and 6 feet in height, founded upon disintegrated chalk, beneath which there is solid chalk.

Topographical Situation.—On the eastern side of a valley running north and south. The station is 40 feet above a small stream in the bottom of the valley and 200 feet below the crest of a ridge which runs E.S.E. to W.N.W., across which the valley is cut. In the bottom of the valley, which is about half a mile in breadth, there is alluvium and grass land. Its eastern side is steep (about 25°) and covered with grass and gorse.

Geological Structure.—The station is on the chalk ridge which forms the backbone of the island. The dip is steep, approaching the vertical, and towards the north. The strike is as given above.[2]

Time-keeping.—Time is obtained from the post-office at Newport, which receives a daily signal from Greenwich. It can also be obtained by noting the time when the sun is due south. For this purpose, in the south wall of the Observatory there is a vertical slit made of two sheets of iron. The image of this is thrown by the sun on to a north wall 16 feet distant. When this image reaches a line on the wall the sun is due south. Accuracy ± 1 sec.

JOHN MILNE

Strassburg, Elsass, Germany.

Lat., 48° 35′ N.; long., 7° 46′ 10″ E.; alt., 135 metres.

Foundation is on compact pure gravel, alluvium.

Topographical Situation.—The instrument is on an isolated pier in water-bearing strata, on the Rhine plain, in the University Garden, 60 metres from Goethestrasse and 65 metres from the Universitätsstrasse, along which heavy traffic is not permitted. The Vosges Mountains are about 20 kilometres distant and the Schwarz Wald about 15 kilometres.

Geological Structure.—On the compact gravel of unknown depth which fills the valley between the above-mentioned ranges. Water-bearing strata are found at a depth of 1·50 metre.

Time-keeping.—Time is kept by means of a Strasser and Rohdesche 'Normal Uhr' (chronometer), in telegraphic connection with the Astronomical Observatory. Weekly, or more frequently, if required, this is compared.

PROFESSOR DR. BR. WEIGAND.

Sydney, N.S. Wales.

Lat., 33° 51′ 41″; long., 10h. 4m. 50·81s. E.; alt., 142 feet.

Foundation is on clay and ironstone shale on sandstone. The seismograph is placed on a glazed brick pedestal about 3 feet from floor, as per instructions sent with the instrument.

Topographical Situation.—On top of a hill 142 feet above sea-level. Gradual slope south and east side, precipitous on north and west side.

The station is an astronomical observatory.

H. R. LENEHAN, Acting Govt. Astronomer.

Toronto, Canada.[3]

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[1] See *Brit. Assoc. Rep.*, 1899.
[2] *Ibid.*, 1896, p. 184, and 1902, p. 60.
[3] *Ibid.*, 1899, p. 170.

Trinidad, West Indies.

Lat., 10° 40′ N.; long., 61° 30′ W.; alt., 66·71 feet above mean sea-level.

Foundation is on hard pan—sand and clay—on a base of concrete 6 feet deep.

Topographical Situation.—On fairly level ground at the foot of a ridge distant about 500 feet and 500 feet in height. In the opposite direction, at a distance of about two miles, is the sea.

Geological Structure.—Yellowish sandy, slaty shale with quartz contortions.

Time-keeping.—Daily astronomical observations are taken by Survey officer.

J. H. HART, Director.

Victoria, British Columbia, Canada.

Lat., 48° 23′ N.; long., 123° 19′ W.; alt., 12 feet.

Foundation.—The instrument is placed upon a concrete pillar (about 18 inches square at top), which goes down 9 feet 6 inches to a bed of hard pan which overlies the native rock of the island.

Topographical Situation.—The station is in the basement of a large three-storey brick building, formerly used as a Custom House. The ground floor of this building is on the water-front street, from which there is a gradual slope down to a wharf; the basement is about 10 feet below the level of this street, and from the street the city gradually rises up a further incline of about 150 feet.

The nearest hill is Mount Douglas, 696 feet altitude, distant between four and five miles to the north-eastward.

To the westward, about 12 to 14 miles away across the water (sea) known as Royal Roads (the entrance to Esquimalt Harbour), lies the range of mountains the Sooke Hills, running north-west and south-east, and reaching about 1,000 feet altitude. These hills are outlying parts of the great mountain ranges which form the backbone of Vancouver Island, with peaks reaching an altitude of 6,000 feet.

Twenty miles to the southward, across the Straits of Juan de Fuca, is the northern coast of the State of Washington, and from the water's edge rise in successive tiers, running east and west, the splendid chain of mountains known as the Olympian Range, whose summits attain 8,000 feet of altitude. These summits are distant from Victoria from 60 to 75 miles.[1]

Geological Structure.—Dr. G. M. Dawson, the late Director of Geological Survey of Canada, says on page 88 of his Report, 1876–77:—

'Volcanic action has played a large part in the building up of these rocks of Vancouver Island, and near Victoria probably nine-tenths of their entire thickness is made up of ashbeds, interleaved with lavas and other igneous rocks. These, from their composition, have yielded readily to metamorphism, and now lithologically resemble, as you have pointed out, the rocks of the Huronian and altered Quebec groups of Eastern Canada. This likeness, with the fact that the rocks still preserve not alone the chemical, but also in some places the mechanical, characteristics of volcanic rocks,' &c.

Mr. W. L. Sutton, a well-known resident geological expert, says that the Victoria rock is dense, igneous, and quite massive, with comparatively little jointage, and closely allied to diabase in general character.

Time.—This is not an astronomical observatory, but our chronometer is rated at least once a week by comparison with the time which is given over the Canadian Pacific Railway telegraph, from the Montreal Astronomical Observatory; our office telegraph being switched on to the local C.P.R. telegraph office and communication received direct from Montreal.

E. BAYNES REID, Superintendent.

III. *The Origins of Large Earthquakes in* 1904.

The number of earthquakes recorded at Shide in 1904 was eighty-three. The localities from which twenty-eight of them originated are

[1] See *Brit. Assoc. Rep.*, 1899, p. 172.

indicated by their Shide register number on the accompanying map. They are distributed as follows :—

District E (Japan—Formosa)	12
District F (Java to Fiji)	9
District F (Himalayan Line)	4
District M (New Zealand Fold)	3

Large earthquakes do not appear to have been noted in any other districts. From 1899 to 1902 there was marked activity in the Alaskan, Cordillerean and Antillean regions. This has gradually waned, whilst activity on the opposite side of the Pacific has not undergone any marked change. M is a district brought into notice by records brought home by the 'Discovery.' These show that to the south-west of New Zealand there is a region where geotectonic changes are much more marked than has hitherto been supposed.

IV. *On International Co-operation for Seismological Work.*

In the British Association Report for 1904, p. 45, a short statement is given of efforts which have been made to establish international inquiry about earthquakes. Amongst other matters, reference is made to a Committee appointed by the International Association of Academies. This Committee recommends that the Associated Academies should take action with their respective Governments in favour of joining the Seismic Association founded in Strassburg, but proposes changes in the terms of the Convention. One change is to the effect that a State may join the Association either through its Government, or through one of its scientific bodies. Another relates to the choice of a central station, which is left to the General Assembly. At present this is at Strassburg, but the Committee did not consider it was necessary that the locality should be named in the Convention. Other proposed changes were of a minor character.

These resolutions have been considered by the Seismic Committee of the Royal Society, and His Majesty's Government will be advised to join the German Convention under certain conditions. Three of these are as follows :—That the suggested changes be adopted ; that the United States of America and France are willing to co-operate ; and that seismology receives State aid in Britain.

V. *Tabulation of the Records obtained in Tokyo of the Gray-Milne Seismograph for the Years* 1886–1901. *By* R. D. OLDHAM.

The discussion of the records of the Gray-Milne seismograph was undertaken primarily with the view of detecting any possible effect of the variation in tidal stresses on the frequency of earthquakes, and though the result has been inconclusive, the figures may be useful in some other connection.

The cost of the calculation was defrayed by a grant from the Research Fund administered by the Royal Society ; the work was conducted by Babu Phanindra Lal Ganguli, Research Scholar of the Calcutta University, and consisted in calculating for each shock (1) the exact local time of occurrence ; (2) the lunar time, taking the interval between two successive, similar, meridian passages of the moon as representing twenty-

Tokyo.—Gray-Milne Seismograph, 1886–1901.—*Shocks with Measurable Amplitude.*

I. *Solar Day and Time.*

Hour . .	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
Declination:																									
> 11° N. .	5	9	1	3	6	5	4	9	10	4	6	7	10	5	12	4	6	4	5	3	8	7	9	5	147
< 11°. .	4	3	2	9	4	7	7	7	1	4	3	4	5	5	4	8	4	4	4	6	6	6	7	4	118
> 11° S. .	8	8	9	7	1	3	7	4	9	5	9	8	5	5	6	3	7	6	6	9	4	10	7	9	155
Sum . .	17	20	12	19	11	15	18	20	20	13	18	19	20	15	22	15	17	14	15	18	18	23	23	18	420

II. *Lunar Day and Time.*

Hour . .	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
Declination:																									
> 11° N. .	7	2	8	6	4	0	2	5	10	8	4	6	9	2	4	8	5	4	5	9	5	4	8	6	131
< 11°. .	5	2	3	5	9	7	11	1	5	5	6	6	11	7	8	8	4	6	4	8	8	4	2	3	138
> 11° S. .	8	7	6	3	6	5	4	10	7	6	2	1	7	12	3	4	6	3	10	9	11	7	8	6	151
Sum . .	20	11	17	14	19	12	17	16	22	19	12	13	27	21	15	20	15	13	19	26	24	15	18	15	420

four lunar hours ; and (3) the declination of the sun and the moon at the time of the shock.

The results are tabulated according to the declination and time, the classification being such that each group of shocks represents a period during which the distribution of the tidal stresses was practically uniform. The grouping adopted has also the advantage that, by taking 11° as a limit, and dividing the year into three portions, according as the declination of the sun is greater or less than that limit, we get three almost equal periods, corresponding closely to the four winter months, November, December, January, and February ; the four summer months, May, June, July, and August ; and the spring and autumn months, March, April, September, October respectively.

The discussion of the record as a whole gave no indication of tidal periodicity, differing in this respect from that of the seismograph at Shillong, but this may well be due to the difference in the character of the record. At Shillong only true tectonic earthquakes of a degree of violence corresponding to at least III of the Rossi-Forel scale were registered ; at Tokyo, on the other hand, the greater part of the record is composed of shocks which could not be felt, which were so feeble that, even instrumentally, they could only be detected, not measured, and which are very probably of quite a different nature to the tectonic earthquakes, in which alone the effect of tidal stresses is to be looked for.

If only those shocks which had a measurable amplitude are considered, the distribution is as represented in the second set of tables. The total number of shocks is too small for detailed discussion, but a comparison of the ratio of shocks occurring between the hours of 18 and 6 on the one hand and between 6 and 18 on the other, when the declination is more than 11° north or south, and for the whole record, gives the following result :—

—		Declination >11° N.		Declination >11° S.		All Shocks	
		6 h. to 18 h.	18 h. to 6 h.	6 h. to 18 h.	18 h. to 6 h.	6 h. to 18 h.	18 h. to 6 h.
Solar	No. of shocks .	81	66	74	81	211	209
	Ratio to mean .	1·10	·90	·95	1·05	1·01	1·99
Lunar	No. of shocks .	67	64	65	86	210	210
	Ratio to mean .	1·02	·98	·86	1·14	1·00	1·00

From this it will be seen that in the case of both sun and moon the ratio of shocks occurring in the half-day containing the upper culmination to those occurring in the half-day containing the lower culmination is above the average ratio when the declination is north, and below it when the declination is south. As the rate and range of variation of tidal stresses in Japan is greater in the half-day containing the upper culmination when the declination is northerly, while the reverse is the case when the declination is southerly, this result falls in with the supposition that tidal stresses have some effect, and tend to increase the frequency of earthquakes at the time when they have the greatest range and rate of variation. As regards the effect of the attraction of the sun, this principle may be more briefly expressed : that the ratio of day to night shocks is higher in summer than in winter.

3			19		20		21		22		23		Total
7	5	7	12	12	7	8	11	9	13	10	9	7	409
4	2	5	4	3	4	1	4	1	4	3	3	4	185
0	6	3	2	1	2	1	1	2	4	2	0	5	108
0	1	1	2	3	1	2	1	1	2	3	2	3	64
3	2	2	1	0	1	2	0	2	1	2	2	0	79
3	7	2	2	3	5	6	7	4	3	5	3	5	164
2	4	1	1	5	7	2	9	0	0	1	1	3	139
0	2	0	2	1	1	1	0	0	4	1	3	3	74
0	1	2	0	1	2	0	4	4	1	1	1	2	49
2	0	0	1	5	4	3	2	4	2	3	2	1	129
2	4	3	1	3	3	0	4	2	3	4	5	2	150
0	11	6	8	5	5	3	7	5	6	8	14	9	320
3	45	32	36	42	42	29	50	34	43	43	45	45	1,872
78		5	78		71		84		86		90		1,872

3			19		20		21		22		23		Total
0	3	15	9	9	6	7	9	10	4	11	10	7	382
3	3	1	3	0	6	4	3	4	5	3	4	3	167
3	0	2	1	3	1	1	2	4	0	0	4	0	111
1	0	1	2	0	2	2	1	2	1	5	1	3	65
5	5	3	1	1	0	1	4	2	3	4	0	4	93
4	7	1	3	3	6	1	2	2	3	3	3	5	139
1	2	2	2	3	3	4	1	4	2	5	3	0	165
2	2	2	1	0	0	2	2	2	1	1	4	1	79
2	3	0	0	0	1	3	1	2	0	0	2	1	46
0	1	2	2	5	3	1	1	1	2	3	2	1	88
8	1	3	3	6	1	3	6	3	2	2	2	1	186
6	8	8	14	9	14	3	8	6	7	5	5	5	351
5	35	40	41	39	43	32	40	42	30	42	40	31	1,872
80		8	80		75		82		72		71		1,872

vertical tide
horizontal tid mum horizontal tide-producing force during
of a meridia

Tokyo Gray-Milne Seismograph, 1886–1901

I. *Solar Day and Time.*

Hour	0		1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		21		22		23		Total
Declination																																																	
> 19° N.	4	8	10	8	5	7	7	5	7	[illegible]	8	6	8	7	10	13	10	10	7	11	11	10	5	6	11	8	4	10	13	9	8	8	7	11	9	7	7	12	12	12	7	8	11			11	[illegible]	7	[illegible]
14° 40′ to 19° N.	1	2	2	2	5	2	4	2	5	5	7	2	6	4	8	6	3	7	6	7	8	7	4	4	7	3	2	5	0	8	3	3	3	6	0	2	3	7	4	[illegible]	4	1	4	1	4	3	3	4	185
11° „ 14° 40′ N.	2	6	3	6	1	2	0	6	4	1	0	2	0	2	3	2	1	4	3	1	3	0	3	1	7	6	3	1	0	0	1	1	1	2	2	4	4	0	2	1	2	1	1	2	4	2	0	5	108
9° „ 11° N.	0	1	2	0	3	1	0	1	1	2	2	3	0	1	2	0	2	0	1	0	0	1	0	2	1	0	0	0	2	1	4	4	3	2	0	1	1	0	2	3	1	2	1	1	2	3	2	3	64
6° „ 9° N.	1	3	0	1	0	0	3	2	2	2	2	2	3	3	0	2	1	4	0	0	4	1	1	1	2	2	4	1	0	4	3	2	2	1	4	1	4	0	3	0	1	2	0	2	1	2	2	0	79
0° „ 6° N.	1	3	1	5	4	2	3	7	2	0	3	2	3	3	3	2	4	3	7	4	4	4	1	5	5	2	4	1	4	4	6	4	2	3	1	2	3	4	[illegible]	3	5	6	7	4	3	6	3	6	104
0° „ 6° S.	2	1	3	1	5	3	2	4	1	4	3	4	4	4	4	3	1	2	5	5	5	3	4	[illegible]	2	2	4	4	4	2	3	1	1	2	1	2	3	5	1	5	7	2	9	0	[illegible]	1	1	3	[illegible]
6° „ 9° S.	0	0	1	1	0	1	0	2	0	2	1	0	1	2	3	3	3	1	2	1	2	1	1	1	1	1	3	0	3	2	1	3	2	6	1	3	1	1	2	1	1	1	0	0	4	1	3	3	71
9° „ 11° S.	0	1	2	2	1	2	0	1	2	0	0	1	0	2	2	1	3	0	0	0	0	1	3	[illegible]	1	0	1	0	1	0	1	4	0	0	0	0	1	0	[illegible]	1	2	0	4	4	1	1	1	2	41
11° „ 14° 40′ S.	1	4	1	2	3	4	2	0	0	0	1	3	2	6	5	8	4	4	1	[illegible]	3	1	2	[illegible]	5	3	2	3	2	0	2	6	3	2	5	0	4	2	[illegible]	5	4	3	2	4	2	3	2	1	129
14° 40′ „ 19° S.	2	3	3	1	2	3	2	4	3	1	1	1	2	6	4	2	3	7	0	3	9	3	3	0	2	1	4	4	7	4	4	5	3	2	6	7	3	3	1	3	3	0	4	2	3	4	5	2	150
> 19° S.	5	10	7	8	7	6	10	11	6	6	2	8	6	6	6	5	8	5	9	8	5	6	7	11	3	6	5	5	7	6	2	7	5	9	4	9	8	6	8	5	5	3	7	[illegible]	6	8	14	3	320
Sum	19	42	35	37	36	34	33	45	32	27	32	33	35	46	50	47	42	46	41	45	[illegible]	37	[illegible]	7	47	34	36	34	43	40	38	48	32	46	33	39	42	38	[illegible]	42	42	29	50	34	43	44	45	45	1 872
Sum by hours	61		72		69		78		59		65		81		97		88		86		86		71		81		70		83		86		78		72		80		78		71		84		86		90		1 872

NOTE.—Two shocks occurring at declination 0° are included in the totals.

II. *Lunar Day and Time.*

Hour	0		1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		21		22		23		Total
Declination																																																	
> 19° N.	12	8	9	5	3	8	10	3	15	6	4	12	13	12	13	11	6	8	7	8	5	6	8	7	7	11	7	6	7	11	7	4	7	10	6	7	4	5	9	9	6	7	9	11	4	11	10	7	382
14° 40′ to 19° N.	3	6	10	2	2	5	3	3	1	5	1	2	3	7	2	4	5	0	3	6	2	4	2	3	4	3	2	2	4	4	2	6	4	0	5	3	4	5	3	0	6	4	3	4	5	3	4	3	167
11° „ 14° 40′ N.	1	2	2	2	1	2	3	0	2	3	1	4	3	0	1	3	4	4	2	4	3	4	7	3	2	5	1	3	5	4	2	2	0	3	1	5	0	1	1	3	1	1	2	4	0	0	4	0	111
9° „ 11° N.	2	2	0	1	0	1	1	0	1	1	1	3	1	2	1	1	2	0	1	1	0	0	1	1	0	2	0	3	2	0	2	2	2	1	0	3	1	4	2	0	2	2	1	2	1	5	1	3	65
6° „ 9° N.	3	0	2	2	2	1	6	5	3	2	1	3	1	0	1	1	1	1	1	2	2	3	3	0	5	3	3	1	3	0	0	1	2	2	0	1	4	3	1	1	0	1	1	2	3	4	0	4	93
0° „ 6° N.	2	2	2	4	2	4	4	7	1	1	4	2	3	2	6	2	1	4	1	5	2	7	1	1	5	4	3	3	0	3	2	1	3	4	3	1	2	4	3	3	6	1	2	2	3	3	3	5	139
0° „ 6° S.	6	1	4	3	7	5	1	2	2	6	8	5	3	1	6	2	6	1	5	2	3	1	3	1	4	5	4	3	7	2	7	4	3	1	4	3	5	3	2	3	3	4	1	4	2	5	3	0	165
6° „ 9° S.	2	8	3	2	2	1	2	2	2	1	3	1	0	1	4	2	0	6	1	0	1	0	0	2	0	2	0	1	2	0	3	1	2	2	1	0	4	4	1	0	0	2	2	2	1	1	4	1	79
9° „ 11° S.	0	0	2	0	1	2	2	3	0	1	0	1	0	1	1	0	3	0	4	2	2	0	2	1	1	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	1	3	1	2	0	0	2	1	46
11° „ 14° 40′ S.	1	2	2	5	4	2	0	1	2	3	4	0	1	4	2	3	2	2	2	6	0	4	0	2	1	1	2	1	1	0	3	1	1	1	1	0	2	2	2	5	3	1	1	1	2	3	2	1	88
14° 40′ „ 19° S.	4	3	3	4	4	3	8	1	3	5	4	2	4	4	5	5	8	4	5	6	7	1	5	1	6	8	7	2	2	3	2	2	4	5	3	4	6	4	3	6	1	3	6	4	2	2	2	1	186
> 19° S.	11	8	7	4	11	8	6	8	8	6	10	6	11	10	7	6	7	9	8	3	10	8	7	8	7	7	6	12	10	6	6	7	9	3	3	4	5	4	14	9	14	[illegible]	8	6	7	5	5	5	351
Sum	47	39	46	34	39	42	45	35	40	40	41	41	43	41	49	40	45	39	40	44	37	38	33	30	42	53	34	37	44	33	37	32	38	33	28	32	37	38	41	39	43	32	40	42	30	42	40	31	1,872
Sum by hours	86		80		81		80		80		82		84		89		84		84		75		63		95		71		77		69		71		60		75		80		75		82		72		71		1,872

Figures in italic indicate the half-hour in which the vertical tide-producing force reached its maximum.

Figures in black indicate the half hour in which the horizontal tide producing force reached its maximum, except in the case of declinations 14° 40′ to 19°, when they indicate the passage of the circle of maximum horizontal tide-producing force during one of three successive half-hours on either side of a meridian passage.

Experiments for improving the Construction of Practical Standards for Electrical Measurements.—Report of the Committee, consisting of Lord RAYLEIGH (*Chairman*), Dr. R. T. GLAZEBROOK (*Secretary*), Lord KELVIN, Professors W. E. AYRTON, J. PERRY, W. G. ADAMS, *and* G. CAREY FOSTER, Sir OLIVER J. LODGE, Dr. A. MUIRHEAD, Sir W. H. PREECE, Professors A. SCHUSTER, J. A. FLEMING, *and* J. J. THOMSON, Dr. W. N. SHAW, Dr. J. T. BOTTOMLEY, Rev. T. C. FITZPATRICK, Dr. G. JOHNSTONE STONEY, Professor S. P. THOMPSON, Mr. J. RENNIE, Principal E. H. GRIFFITHS, Sir A. W. RÜCKER, Professor H. L. CALLENDAR, *and* Mr. GEORGE MATTHEY.

THE Committee are glad to report that satisfactory progress has been made during the year with the Ampère Balance.

The weighing mechanism was taken over from the maker shortly after the last meeting of the Association and the work on the coils completed at the National Physical Laboratory. The labour involved in insulating the two wires on the large cylinders was very great. Each wire consists of about ninety turns of about 103 centimetres circumference. Thus each wire is about 93 metres in length, and the two are along their whole length about one-tenth of a millimetre apart. In the coils as finally set up the insulation resistance between these two wires is measured in thousands of megohms, and is thus amply sufficient.

The cost of the balance has amounted to 302*l*. 6*s*., the excess over the 300*l*. granted for the purpose being met out of the general fund at the disposal of the Committee.

Calculations of the force to be expected between the coils when carrying one ampère have been made by Mr. Mather and Mr. F. E. Smith, of the National Physical Laboratory, and are in close agreement.

The designs from which the balance has been made are the work of Mr. Mather, and originally it was contemplated that the balance would be set up at the City and Guilds Central Institute in Exhibition Road. At a meeting of the Committee held on March 31, 1905, however, this decision was modified, and the following minute agreed to :—

That the Ampère Balance remains for the present at the National Physical Laboratory, and that a determination of the ampère be made with it there under the supervision of Professor Ayrton and Mr. Mather, steps being taken to connect closely with the determination and with any notification of the results the names of the late Professor J. V. Jones, Professor Ayrton, and Mr. Mather, to whom the design of the instrument is entirely due.

Accordingly the balance has been set up at the National Physical Laboratory and a number of preliminary tests have been made. Particulars of some of these follow.

Ampère Balance.—The weighing mechanism of the balance was erected by Mr. L. Oertling at the National Physical Laboratory in March of the present year, and the electrical equipment was completed

immediately afterwards. The four coils of bare copper wire wound on marble cylinders have given complete satisfaction, the ellipticity and conicality of each being very small. The average ellipticity is such that the diameters of the ellipse differ in length by about 10 micron, while the average conicality is approximately represented by a difference between the mean diameters of two sections 13 cm. apart (the axial length of one coil) of about 12 micron. The contour of the cylinders is very well known, and the mean diameter has been measured with a probable error not greater than 0·001 per cent. This knowledge enables the calculation of the mutual induction between two coils to be made with great accuracy.

Preliminary observations with a current of nominal value 1 ampère were made at various times during April and May, the first set of such observations determining the temperature to which the coils are raised by a continuous steady current, the magnitude of the disturbances arising from convection currents, the influence of the silver strips, and the nature of other disturbances. The convection currents give some trouble, but the experiments already carried out indicate that a change of 0·001 per cent. in a current of nominal value 1 ampère will be detectable.

The balance acts conveniently as an indicator of the magnetic permeability of the marble and metal parts of which it is constructed, and it is satisfactory to know that the permeability of these parts does not differ from unity by a measurable amount, and cannot therefore influence the final results.

Early observations showed that the concentric cable employed in the leads to the balance was faulty, some of the internal strands being broken, and the variable contacts thus resulting prevented a steady current from being obtained. Fresh concentric cable is being inserted, which should enable the final observations to be speedily made.

Apparatus for the determination of 'g.'—The three half-second pendulums (the property of the Board of Education, and which were used in the last Antarctic expedition) have been swung at Kew and at the National Physical Laboratory in the room where the balance is erected. The observations are being continued.

When all the constants have been determined and the observations with the balance are complete it will be necessary to consider the means by which the result is to be given to the world. The current may be reproduced either by means of the silver voltameter or by means of a standard cell and a standard resistance. The silver voltameter is being investigated at the National Physical Laboratory, and a comparison of the accuracies of reproduction would perhaps influence the choice.

The Committee were represented at the International Electrical Congress at St. Louis last year by Professor Perry and the Secretary.

The resolutions passed at the Cambridge Meeting of the Committee (see Report for 1904) as to certain questions proposed for discussion were laid before the Congress, and after discussion the following reports were unanimously accepted :—

Committee of the Chamber of Delegates on International Electro-magnetic Units.

The Sub-Committee appointed September 13, 1904, beg leave to suggest that the Chamber of Delegates should adopt the following report :—

It appears from papers laid before the International Electrical Congress and from the discussion that there are considerable discrepancies between the laws relating to electrical units, or their interpretations, in the various countries represented, which, in the opinion of the Chamber, require consideration with a view to securing practical uniformity.

Other questions bearing on nomenclature and the determination of units and standards have also been raised, on which, in the opinion of the Chamber, it is desirable to have international agreement.

The Chamber of Delegates considers that these and similar questions could best be dealt with by an International Commission representing the Governments concerned. Such a Commission might, in the first instance, be appointed by those countries in which legislation on electric units has been adopted, and consist of, say, two members from each country.

Provision should be made for securing the adhesion of other countries prepared to adopt the conclusions of the Commission.

The Chamber of Delegates approves such a plan, and requests its members to bring this report before their respective Governments.

It is hoped that if the recommendation of the Chamber of Delegates be adopted by the Governments represented the Commission may eventually become a permanent one.

Committee of the Chamber of Delegates on International Standardisation.

The Committee of the Chamber of Delegates on the Standardisation of Machinery beg to report as follows :—

That steps should be taken to secure the co-operation of the technical societies of the world by the appointment of a representative Commission to consider the question of the standardisation of the nomenclature and ratings of electrical apparatus and machinery.

If the above recommendation meets the approval of the Chamber of Delegates it is suggested by your Committee that much of the work could be accomplished by correspondence in the first instance and by the appointment of a General Secretary to preserve the records and crystallise the points of disagreement, if any, which may arise between the methods in vogue in the different countries interested.

It is hoped that if the recommendation of the Chamber of Delegates be adopted the Commission may eventually become a permanent one.

The first of these Reports, relating to the summoning of an International Congress on Electrical Units, is now under the consideration of His Majesty's Government. Meanwhile a preliminary conference of representatives of standardising laboratories and others interested in the determination of electrical units has been summoned by the President of the Reichsanstalt to meet in Berlin in the autumn. Lord Rayleigh and the Secretary have received invitations to be present.

The object of this Conference is stated to be that the institutions which are concerned in maintaining the accuracy of electrical measurements in conjunction with those scientists who have devoted especial attention to this field of work should exchange opinions, and if possible come to an agreement as to the measures which must be taken in order to obtain the international uniformity in electrical units and measurements which is desired. It is thus preliminary to the more formal consideration of the subject, which would be the work of the International Congress.

One of the important questions which will be discussed will be the specification of some form of standard cell. Work on this matter has gone on in America and at the National Physical Laboratory, and an Appendix to the Report by Mr. Smith contains a provisional specification.

It is suggested that persons interested in the matter might help by setting up cells in accordance with this specification and submitting them for test at the laboratory.

Of the grant made to the Committee in 1904 a balance of 3*l.* 4*s.* 10*d.* remains.

The work which remains to be done on the standard cell, and with the Ampère Balance, will all involve considerable expense, and to meet this the Committee ask for reappointment, with a grant of 25*l.* in addition to the balance now in their hands.

APPENDIX.

On the Preparation of a Cadmium Cell. By F. E. Smith.

(From the National Physical Laboratory.)

The research on standard cells has been continued at the National Physical Laboratory on the lines indicated in the last Report to the Association. Taken as a whole, the results are very satisfactory, but it is thought desirable to still continue the observations on some of the older cells before publishing the results in detail.

Mr. G. A. Hulett, of Michigan, has completed a chemical research on mercurous sulphate, which throws considerable light on the anomalies reported to the Association last year. Very slight changes can still, however, be traced to this salt, but fortunately they are of no commercial significance. The $12\frac{1}{2}$ per cent. amalgam also produces slight variations in the E.M.F. of the cell : these again are commercially unimportant, and a manner of overcoming them in cells employed at a standards laboratory is indicated in this paper. The latter cells are set up with an amalgam entirely liquid at 0° C.

At this stage of the research it is thought desirable to describe the methods by which the materials of the cell can be best prepared in the light of present information, and an appeal is made to those interested in the subject to set up one or more cells by these methods and submit them for comparison with the standards of the National Physical Laboratory. More light will thus be thrown on the slight discrepancies already referred to, and the degree of accuracy with which the cell can be constructed will be established. In this way it is hoped to specify a cell for commercial purposes accurate at all ordinary English working temperatures to 1 part in 2,000, applying no temperature correction, or to 1 part in 10,000 if the temperature correction be applied.

In the specification which follows there are four methods of preparing the mercurous sulphate. The first of these is due to Professor H. S. Carhart, Mr. G. A. Hulett, and Dr. Wolff, jun. ; the main features of the second method were suggested by Mr. Swinburne to Dr. Glazebrook, while the third and fourth methods have resulted from some experiments at the National Physical Laboratory. It is suggested that one only of these methods be eventually employed ; the observations on submitted cells will largely determine the choice.

Preparation of Materials for a Standard Cadmium Cell.

1. *Mercury.*—The commercial mercury should be squeezed through wash-leather and passed in the finely divided condition in which it emerges, first through dilute nitric acid (1 to 6 of water) and mercurous nitrate solution, and afterwards through distilled water, both liquids being conveniently contained in long glass tubes. The mercury is then to be twice distilled *in vacuo.* Mercury suspected of abnormal contamination should not be employed.

2. *Amalgam.* Type A.—This is a $12\frac{1}{2}$ per cent. amalgam, and is intended for all commercial cells. The method of preparation is practically identical with that used by Professor Carhart. A current is passed from a thick rod of pure commercial cadmium to distilled mercury, the intervening liquid being cadmium sulphate solution rendered slightly acid with a few drops of H_2SO_4. The kathode is weighed before deposition takes place, and again afterwards, the percentage of cadmium in the amalgam being thus calculable. More than the requisite amount should always be deposited, and the percentage reduced to $12\frac{1}{2}$ by the addition of more mercury. The fall of potential from anode to kathode should not exceed 0·3 volt. To prevent the anode slime having access to the kathode it is desirable to surround the anode with a small porous pot, as in the Richards silver voltameter, or to place a small crystallising dish beneath it for the anode powder to settle in. Contact with the kathode is made with a platinum wire sealed into a glass tube so as to protect it from direct contact with the cadmium sulphate solution, and a rough estimate of the quantity of cadmium deposited is obtained from the readings of an ammeter placed in the circuit. The amalgam so prepared, together with the mercury added to reduce the percentage of cadmium to $12\frac{1}{2}$, is now heated on a water-bath and stirred so as to ensure homogeneity, some cadmium sulphate solution still flooding the surface. It is then cooled and the acid sulphate removed, neutral cadmium sulphate solution taking the place of the latter, and consisting of saturated solution *plus* an equal volume of distilled water. This $12\frac{1}{2}$ per cent. amalgam is then ready for use and is entirely liquid at a temperature approximating to 60° C.

Type B.—This amalgam is liquid at the temperature of melting ice, and is intended for cells of a slightly better type than those made with the $12\frac{1}{2}$ per cent. amalgam. The cells may be used at a higher temperature than 0° C., but they are not intended to be so used as their temperature coefficient is about −0·043 per cent. per rise in temperature of 1° C. The cells are primarily intended for standardising laboratories, and their E.M.F. at 0° C. is equal to the E.M.F. of the cells prepared with the A amalgam if this latter E.M.F. is corrected to 0° C. with the temperature coefficient formula of the cell. This is equivalent to saying that if an A cell was in a steady condition at 0° C. and nothing abnormal occurred its E.M.F. would be identical with that of a B cell at 0° C. It is not wise, however, to use a $12\frac{1}{2}$ per cent. amalgam cell at low temperatures; an 8 per cent. amalgam may be so used, but its upward range (with a small temperature coefficient) is lower than that of the $12\frac{1}{2}$ per cent. amalgam cell. For commercial purposes probably the $12\frac{1}{2}$ per cent. amalgam will be of most service.

To prepare the type B amalgam take some of that previously prepared and add sufficient mercury to reduce the percentage of cadmium to 3.

The amalgam will now be entirely liquid at ordinary working temperatures. On cooling, a crystalline amalgam separates from the liquid, and will continue to do so as the temperature is lowered. Cool the amalgam to the temperature of melting ice and remove the mother liquid : this is the amalgam desired. It is important that the temperature be truly that of melting ice, and that no solid is removed. For convenience the 3 per cent. amalgam may be placed in a tubular vessel well surrounded with ice shavings ; a long very fine capillary tube reaches to the base of this vessel, and through it the liquid at 0° C. is removed by suction. Some solid must be left behind, or otherwise there is no certainty of saturation. Throughout all the operations neutral cadmium sulphate solution must cover the surface of the amalgam and wet all vessels, tubes, &c., through which the amalgam passes. Otherwise the amalgam will leave a 'tail' and its composition may possibly be thereby changed.

3. *Cadmium Sulphate Crystals and Solution.*—Procure commercially pure cadmium sulphate $CdSO_4 8/3 H_2O$. Dissolve in about $1\frac{1}{4}$ time its weight of distilled water, agitating either continuously for about six hours or occasionally for two or three days. Filter through a fine-grained filter paper so as to ensure a clear solution, which should then be placed in a number of crystallising dishes and evaporation allowed to take place slowly at a temperature not exceeding 35° C., when, provided that dust be excluded, many transparent crystals of $CdSO_4 8/3 H_2O$ will result. These should be prevented as much as possible from adhering to one another by removing the liquid to other dishes as soon as the crystals are of such a size that most of them are in contact. In this way about five-sixths of the liquid may be evaporated, the mother liquid being employed for a preliminary washing of the mercurous sulphate, the manufacture of which is afterwards described. The crystals of cadmium sulphate so obtained should be washed with successive small quantities of distilled water until after standing for five minutes no trace of acidity can be detected with congo red. The crystals, still moist, may then be transferred to a stock bottle. To prepare the final solution agitation with distilled water is recommended as before, the temperature being preferably 5° or 10° higher than the normal temperature, so as to ensure saturation. On no account should cadmium hydroxide be employed to neutralise the first solution, which is invariably acid ; nor indeed should any attempt be made to neutralise the solution except by crystallisation.

4. *Mercurous Sulphate.*—The preparation in each case is to be conducted in a darkened room.

(*a*) *Electrolytic Method.*—Pure distilled mercury forms the anode and platinum foil the kathode, the electrolyte being dilute sulphuric acid (1 part by volume of concentrated acid to 5 parts of distilled water). The mercury is preferably placed in the base of a large flat-bottomed beaker and about twenty times its volume of the dilute acid added. Contact with the mercury is effected by means of a platinum wire passing through a glass tube, while the kathode is suspended in the upper portion of the liquid. During the electrolysis the electrolyte must be continually stirred, an L-shaped glass stirrer being most efficient, the L portion being placed near the surface of the mercury. A current density of about 0·01 ampère may be employed. The salt so prepared is treated as per note A.

(*b*) Precipitation method, mercurous nitrate and sulphuric acid being employed.

Add strong nitric acid to a little pure mercury contained in a crystal-

lising dish and place in a draught chamber until the action is over. If any mercury remains add more acid and continue to do so until the mercury has completely disappeared and a strongly acid solution assured. Prepare dilute H_2SO_4 (1 to 4 by volume), allow to cool, and then add the acid nitrate solution drop by drop, keeping the mixture violently agitated. Mercurous sulphate is precipitated, which should be filtered and treated as per note A. No more nitrate solution must be added to the dilute H_2SO_4 than will suffice to neutralise 30 per cent. of the H_2SO_4 present. The maximum amount it is permissible to add may be estimated by taking a small portion of the dilute H_2SO_4 and adding the nitrate solution until no further precipitation results. The proportion of nitrate solution to dilute H_2SO_4 in such circumstances must be reduced to one-third its value for the preparation of mercurous sulphate by method *b*.

(*c*) Precipitation method, strong and dilute sulphuric acid being employed.

Purchased mercurous sulphate is warmed with pure strong H_2SO_4 and a little mercury to a temperature of about 150° C. for about ten minutes, the operation being conducted in an evaporating dish covered with a clock glass and the mixture kept well stirred. The suspended matter is then allowed to settle, the hot liquid cooling sufficiently meanwhile for the vessel to be handled with comfort. The clear acid is then poured into dilute H_2SO_4 (1 to 6), when crystalline mercurous sulphate separates out. About ten times the bulk of dilute acid should be employed, and to avoid spitting the hot liquid should be poured through a funnel, having its stem immersed in the dilute acid. The mixture is well stirred, cooled, and filtered, and the salt treated as per note A. As the operation yields but a small quantity of the salt, it is advisable to repeat several times.

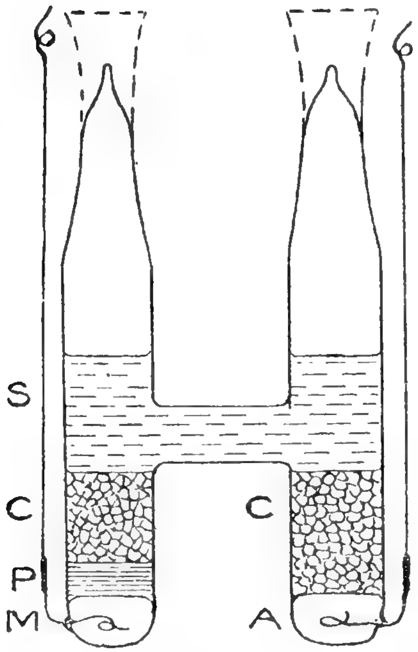
(*d*) By means of Nordhausen sulphuric acid.

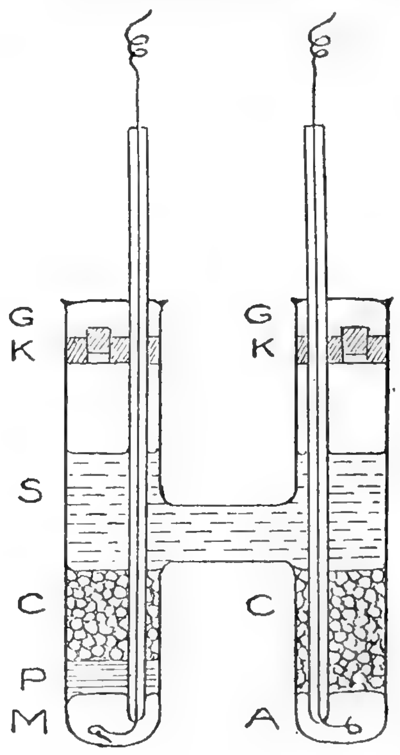
Place distilled mercury in the bottom of a beaker or bottle to the depth of about 3 mm. Add about four times its volume of Nordhausen sulphuric acid and stir well, keeping the mouth of the bottle closed as much as possible, as the acid fumes are very unpleasant. Mercurous sulphate is formed in the cold and appears in the crystalline form after a few minutes. Allow the operation to continue until the acid strength has been considerably diminished; warm the product to expel SO_2 and add to dilute H_2SO_4 (1 to 6). Considerable spitting always occurs, so that caution is necessary. Proceed with the product as per note A.

NOTE A.—The mercurous sulphate obtained by the foregoing methods is first agitated with dilute H_2SO_4 (1 to 6) and distilled mercury. It is then filtered (a small Gooch crucible and filter flask are convenient), and the greater part of the mercury removed as it interferes with the filtering. The salt is next washed with small quantities of saturated cadmium sulphate solution until free from acid. For the first few washings some of the first acid solution may be employed, but the final washings must be made with a little of the neutral solution. Trouble is often experienced in ridding the salt prepared with Nordhausen sulphuric acid from all trace of acidity, and it is preferable to wash five or six times with the cadmium sulphate solution, and then place in a bottle together with a little of the solution, shaking from time to time and filtering again in a few days. The acidity of the washing liquid should be tested with congo red. Instead of washing with cadmium sulphate solution, sulphuric ether (water free) may be employed.

The Mercurous Sulphate Paste.—Some cadmium sulphate crystals are ground in an agate mortar with a little cadmium sulphate solution; about one-quarter their bulk of pure mercury is then added and two volumes of the acid-free mercurous sulphate, the whole being well mixed with cadmium sulphate solution so as to form a thin paste.

The Form of Cell.—The H form of cell due to Lord Rayleigh is the most convenient, and is in general use. Two patterns have been adopted. In fig. 1 a form is shown in which the electrodes are sealed into the lower ends of the two vertical limbs, while in the form shown in fig. 2 the electrodes pass through glass tubes into the lower ends of which they





M = Mercury.
A = Amalgam.
P = Paste.
C = Cadmium sulphate crystals.

S = Saturated solution of cadmium sulphate.
K = Cork.
G = Marine glue.

are sealed. Form 1 can be hermetically sealed, and is intended to be immersed in an insulating liquid. Form 2 is sealed with marine glue, and may be immersed in ice or water. The hermetical sealing of form 1 was suggested by Lord Rayleigh [1] and by Professor Carhart.[2] The glass tubes through which the electrodes are introduced in form 2 pass through corks which have been previously boiled in water and soaked in cadmium sulphate solution; in addition to the hole allowing of the passage of the electrodes, a second hole is bored through these corks for the passage of small glass pipettes. After the cell is filled these additional holes are

[1] *Phil. Trans.*, 176, § 42, 1886.

[2] St. Louis Congress, 1904.

fitted with small corks, and the cell is finally sealed with marine glue. The position of the various parts is shown in the figure. (Both forms of glass vessels are stocked by Mr. A. C. Cossor, of 54 Farringdon Road, E.C.)

In filling the vessels it is convenient to use small pipettes made of two glass tubes, the one about 3 inches long and $\frac{1}{2}$ inch in diameter, and the other about 2 inches long and $\frac{1}{3}$ inch in diameter. If the larger tube has one end drawn out in the form of a cone, a junction is easily made. The amalgam of type A is melted over a water-bath (its surface being flooded with dilute cadmium-sulphate solution), and is introduced by means of a previously warmed pipette into one of the limbs. After the amalgam has solidified this limb should be washed out with a little fresh cadmium-sulphate solution. If the amalgam of type B is used this washing is unnecessary. The mercury is next introduced into the other limb, then the paste, using if necessary a tiny glass rod as a piston through the pipette, and afterwards a thick layer of finely pounded crystals is introduced into each limb. Saturated cadmium-sulphate solution is finally added. The cells are then to be exposed in a warm room for a week or more to allow some of the liquid to evaporate, and so loosely cement together the fine crystals. This crystalline plug keeps the contents in their proper places, and enables the cell to be transmitted through the post. The sealing of the cells is next completed, care being taken not to abnormally heat the contents.

Cells which are submitted for comparison with the standards of the National Physical Laboratory should be accompanied with the following particulars :—

1. Maker's name and address.
2. Name[1] of the firms from whom the chemicals used in the manufacture of the materials were purchased
3. Number of the method employed in the manufacture of the mercurous sulphate.
4. Type of cadmium amalgam used.
5. Notes on any peculiarities observed in the preparations.

The Transformation of Aromatic Nitroamines and Allied Substances, and its Relation to Substitution in Benzene Derivatives.—Report of the Committee, consisting of Professor F. S. KIPPING (*Chairman*), Professor K. J. P. ORTON (*Secretary*), Dr. S. RUHEMANN, Dr. A. LAPWORTH, *and* Dr. J. T. HEWITT.

I. *Nitroamines.*

THE nitroamines of the benzene series, which were discovered by Bamberger (1893), exhibit in a very marked degree a property frequently found in analogous derivatives of anilines—namely, of changing into an isomeride in which the group, the nitro group, &c., originally linked to the nitrogen atom, has become attached to the ortho or para carbon atom of the nucleus.

The mechanism of this has in the case of the nitroamines been but

[1] This information is only required so that the number of different sources of the materials can be estimated.

little studied. It was thought that some light might be thrown on the mechanism of the change by studying the behaviour of s-trisubstituted nitroamines in which it is impossible for the nitro group to wander to the ortho or para position without displacing the atom or group already attached at that point to the nucleus. Such s-trisubstituted nitroamines can now be easily prepared,[1] and those in which chlorine or bromine occupy the 2 : 4 : 6 positions were selected for investigation.

It was ascertained that when subjected to conditions (treatment with sulphuric acid in acetic acid solution) which lead to the isomeric change of unsubstituted nitroamines :—

(i) A series of colour changes occur indistinguishable from those given by the unsubstituted nitroamines whilst they are undergoing the isomeric change ;

(ii) Bromine, in the para position, is partially replaced by the nitro group, a substituted p-nitroaniline being formed ;

(iii) If chlorine occupied the para position, no replacement occurs, but the final product is a quinone derivative. In the case of s-trichloroaniline, hexachlorophenyliminoquinone is produced ; and

(iv) The nitro group never passes into the meta position.[2]

II. *The Exchange of Halogen for Hydroxyl in Benzenediazonium Hydroxides.*

The conversion of s-trihalogenbenzenediazo-compounds, s-trichloro- and s-tribromo-diazobenzene, into the corresponding dihalogen-o-quinone-diazides may be regarded, at least in one of its stages, as an isomeric change ; the ionic hydroxyl $(OH)^{\cdot}$ of the diazonium hydroxide takes the place of the bromine in the ortho or para position, but not in the meta position, the bromine becoming ionic, $Br^{\cdot}$.[3]

The transformation of s-tribromodiazobenzene has been more fully studied, in order to ascertain whether any appreciable quantity of nitrosoamine, $C_6H_2Br_3.NH.NO$, was also formed simultaneously from the diazohydroxide. It was ascertained that the replacement of halogen by hydroxyl was always the main reaction, and depended little on temperature, between the freezing-point and 15°. The nitrosoamine, if formed, is present in such small amount as not to be capable of certain recognition by means of the β-naphthol derivative.[4]

III. *Influence of Light on Diazo-Reactions.*

A very interesting action of light on solutions of diazonium salts, which hitherto appears to have escaped notice, has been observed.[5] The aqueous, alcoholic (methyl or ethyl), or acetic acid solutions of diazonium salts are sensitive to light. On exposure nitrogen is evolved, the acid radical appears as free acid, and the phenol, its methyl or ether, or its acetate, according to the nature of the solvent, is formed. Many diazonium

[1] Orton, *Trans. Chem. Soc.*, **81**, 806.
[2] *Trans. Chem. Soc.*, **87**, 389.
[3] *Proc. Roy. Soc.*, **71**, 153 ; *Trans. Chem. Soc.*, **83**, 796.
[4] *Trans. Chem. Soc.*, **87**, 99.
[5] *Proc. Chem. Soc.*, 1905, **21**, 168.

salts—as, for example, those of s-tribromodiazobenzene—which do not yield the corresponding phenol (or its derivatives) on heating, decompose nearly quantitatively in this manner under the influence of light.

Wave-length Tables of the Spectra of the Elements and Compounds.—Report of the Committee, consisting of Sir H. E. ROSCOE (*Chairman*), Dr. MARSHALL WATTS (*Secretary*), Sir NORMAN LOCKYER, Professor Sir JAMES DEWAR, Professor G. D. LIVEING, Professor A. SCHUSTER, Professor W. N. HARTLEY, Professor WOLCOTT GIBBS, Sir W. DE W. ABNEY, *and* Dr. W. E. ADENEY.

NEON.

Baly, 'Phil. Trans.' (A) ccii. p. 183, 1903.

Wave-length	Intensity and Character	Liveing and Dewar	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda +$	$\frac{1}{\lambda} -$	
6717·20	1	6716	1·82	4·0	14883·2
6599·16	4	6601	1·79	4·1	15149·3
33·10	4	6535	1·78	,,	15302·6
06·72	6	6508	1·77	4·2	64·5
6444·90	1	6446	1·75	,,	15501·9
09·90	1		1·74	,,	96·7
02·40	10	6404	,,	,,	15604·9
01·26	1		,,	,,	17·7
6383·15	8	6382	,,	,,	62·2
52·04	1		1·73	4·3	15738·7
31·13	1		1·72	,,	90·7
28·38	6	6334	,,	,,	97·5
13·94	1		,,	,,	15833·7
04·99	8	6304	1·71	,,	56·1
6294·04	1		,,	,,	83·7
73·26	1		,,	,,	15936·4
66·66	10	6266	1·70	,,	53·5
59·06	1		,,	,,	72·5
47·00	1	? 6244	,,	4·4	16003·3
17·50	8	6217	1·69	,,	79·2
14·13	2		,,	,,	88·0
06·01	1		,,	,,	16109·0
6199·34	1		,,	,,	26·3
89·30	1		1·68	,,	52·5
82·37	10	6183	,,	,,	70·6
79·90	1		,,	,,	77·1
75·15	2	6176	,,	,,	89·8
73·02	1		,,	,,	95·1
66·81	1		,,	,,	16211·4
63·79	10	6163	,,	,,	19·4
57·12	1		,,	,,	37·0
50·49	1		1·67	,,	54·5
43·28	10	6144	,,	,,	73·5
28·63	8	6128	,,	,,	16302·5
18·22	2		,,	,,	40·2
6096·37	10	6097	1·66	,,	98·7
74·52	10	6075	1·65	4·5	16457·7
64·36	1		,,	,,	85·3

NEON—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Reduction to Vacuum $\lambda+$	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
6046·06	1		1·65	4·5	16535·2
43·24	1		,,	,,	42·9
32·32	2 }	6031	1·64	,,	72·9
30·20	10 }		,,	,,	78·7
26·03	1		,,	,,	90·2
24·40	1		,,	,,	94·7
01·00	1	6001	1·63	,,	16659·4
5991·72	2	5991	,,	,,	85·2
88·00	4	5987	,,	,,	95·6
84·94	1		,,	,,	16704·1
75·78	8 }	5976	,,	,,	29·7
74·73	6 }		,,	,,	32·7
65·50	4	5964	1·62	,,	58·5
61·64	1		,,	4·6	69·3
49·51	1		,,	,,	16803·5
44·91	10	5945	,,	,,	26·5
39·44	1		,,	,,	32·0
19·08	1	5919	1·61	,,	89·9
13·82	1	5914	,,	,,	16904·9
06·54	2	5905	,,	,,	25·8
02·57	4		,,	,,	37·2
5882·04	8	5882	1·60	,,	96·3
73·04	1		,,	,,	17022·3
* 52·65	20	5852·7	1·59	,,	81·7
20·29	4	5820	,,	,,	17176·7
04·57	1	5804	1·58	4·7	17223·1
5764·54	8 }	5763	1·57	,,	42·7
64·20	1 }		,,	,,	43·8
60·72	1		,,	,,	54·2
48·44	4	5747	,,	,,	91·3
19·42	1	5718	1·56	4·8	17479·4
5689·96	2	5689	1·55	,,	17570·0
62·76	1	5662	1·54	,,	17654·4
56·80	4	5656	,,	,,	73·0
52·67	1		,,	,,	85·9
5562·96	2	5561·	1·52	4·9	17971·1
5433·86	1	5432	1·48	,,	18398·2
00·77	4 }	5400 (a pair)	1·47	5·1	18510·8
00·50	4 }		,,	,,	11·7
5343·41	1 }	5341 (a pair)	1·46	,,	18689·5
41·25	4 }		,,	,,	18717·1
32·33	4	5330	1·44	,,	48·4
5278·50	1		,,	5·2	18899·6
71·50	1		,,	,,	18964·7
18·30	1		1·43	,,	68·1
04·12	1	5204	1·42	5·3	19210·2
5188·79	1	5188	,,	,,	67·0
45·15	1	5145	1·41	,,	19434·5
16·72	1	5116	1·40	5·4	19538·3
5880·54	1	5080	1·39	,,	19677·5
37·95	1	5038 (strong line)	1·38	,,	19843·9
4837·54	1	4838	1·32	5·7	20666·0
06·24	1		,,	,,	20800·6

* Extraordinarily brilliant.

NEON—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
4789·07	1	4791	1·31	5·7	20875·3
52·88	1	4754	1·30	5·8	21034·4
15·49	4	4715	1·29	,,	21200·9
13·51	2		,,	,,	09·8
12·23	2		,,	,,	15·6
10·21	2		,,	,,	24·7
09·00	4	4710	,,	,,	30·1
04·56	4	4704	,,	5·9	51·2
4540·48	1	4540	1·24	,,	22018·8
37·39	1	4538	,,	6·1	33·0
10·86	1		,,	,,	22162·2
4459·68	1	4460	1·22	6·2	22416·9
31·14	1	4431	,,	6·3	22561·3
30·33	1	4429	1·21	,,	65·6
26·15	2		,,	,,	87·7
25·57	1		,,	,,	90·7
24·98	2	4424	,,	,,	93·7
22·69	2	4422	,,	,,	22604·4
14·44	1	4413	,,	,,	46·6
4259·53	6	4258	1·17	6·5	23470·3
01·03	4		1·15	6·6	23797·1
4198·71	4	4198	,,	,,	23810·2
91·44	2		,,	,,	51·5
90·86	2		,,	,,	54·8
82·00	2		,,	,,	23906·4
58·68	4		1·14	,,	39·5
3899·21	1	3900	1·08	7·3	25638·9
86·26	1		1·07	,,	25724·4
79·49	1		,,	,,	69·3
3754·31	2	3754	1·04	7·5	26628·5
01·30	6	3701	1·03	7·6	27009·9
3685·84	4	3686	1·02	,,	23·2
82·33	4	3683	,,	7·7	49·0
33·78	6	3634	1·01	7·8	27511·7
09·27	2	3609	1·00	,,	27698·6
06·61	1		,,	,,	27719·0
00·24	4	3600	,,	,,	68·1
3593·67	10	3593	,,	7·9	27818·8
88·60	1		,,	,,	58·1
87·52	1	3587·5 (a pair)	,,	,,	66·5
87·24	1		,,	,,	68·7
86·62	1		,,	,,	73·5
67·73	1		0·99	,,	28021·1
54·39	1		,,	,,	26·4
32·30	1		0·98	8·0	28301·9
29·95	1		,,	,,	21·0
22·92	1		,,	,,	77·5
20·57	8	3521	,,	,,	96·5
15·30	6	3515	,,	,,	28439·1
10·87	2	3510	,,	,,	75·0
01·34	6	3500	,,	8·1	28552·4
3498·19	6	3498	0·97	,,	78·1
81·94	1	3481	,,	,,	28711·5
72·70	8	3473	,,	,,	87·9
66·72	6	3467	,,	,,	28837·6

NEON—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3464·48	6	3464	0·97	8·2	28856·2
60·67	6	3460	,,	,,	88·0
54·30	6	3454	0·96	,,	28941·2
50·87	4	3451	,,	,,	70·3
47·83	8	3447·7 ? He	,,	,,	75·5
38·66	1		,,	,,	29072·9
24·05	2	3424	,,	8·3	96·8
18·05	8	3418	,,	,,	29248·2
3375·72	1	3374 ?	0·94	8·4	29514·9
70·01	6	3370	,,	,,	29665·0
3148·76	1		0·89	8·5	31750·1
26·33	1		0·88	8·9	31977·5
3092·84	1		0·87	,,	32323·8
80·05	1		,,	,,	32457·1
77·08	1		,,	,,	88·4
57·50	1		0·86	,,	32696·6

FIRST KRYPTON SPECTRUM, WITHOUT LEYDEN JAR AND SPARK GAP.

*** The figures in parentheses indicate the intensities.

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
6456·65	1	6458 (1)		1·76	4·2	15483·7
6421·32	1	6420 (4)		1·75	,,	15568·9
6236·61	1			1·70	4·3	16030·0
6223·00	1			1·69	,,	39·3
6083·08	1	6082 (1)		1·66	4·5	16434·5
75·50	1			1·65	,,	54·0
56·32	2	6056 (2)		,,	,,	16507·2
12·34	1	6011 (2)		1·64	,,	16628·0
5994·02	2	5992 (3)		1·63	,,	78·8
5880·06	1			1·60	4·6	17002·1
* 71·12	10	5871 (10)	5871·071 (8)	,,	,,	27·9
66·94	1			,,	,,	40·1
32·94	1			1·59	4·7	17139·3
27·28	1			,,	,,	56·0
5756·96	1			1·57	,,	17365·6
18·59	1			1·56	4·8	17482·0
01·06	2			1·55	,,	17535·8
5695·58	1			,,	,,	52·7
60·37	3			1·54	,,	17661·9
49·85	1			,,	,,	94·8
*5580·64	1			1·52	4·9	17914·2
†* 70·50	10	5571 (10)	5570·417 (8)	,,	,,	46·8
‡* 62·45	6	5563 (3)	5562·363	,,	,,	72·8

* Visible in the second Krypton spectrum.
† Probably the green aurora line.
‡ *Cf.* Xenon.

First Krypton Spectrum—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
*5520·74	1			1·51	4·9	18108·6
19·61	4			,,	,,	12·3
00·90	1			1·50	5·0	73·8
5498·24	3			,,	,,	82·6
91·11	1			,,	,,	18206·3
5475·49	2			1·49	,,	58·2
23·44	1	? 5424 (1)		1·48	,,	18433·5
4829·90	3			1·32	5·7	20698·7
07·22	4			,,	,,	20796·3
4792·80	1			1·31	,,	20858·9
34·32	4			1·30	5·8	21116·6
4697·17	4			1·29	5·9	21283·6
91·12	2			1·28	,,	21311·0
71·40	10		4671·42 (2)	,,	,,	21401·9
24·48	10		4624·46 (1)	1·27	6·0	21618·0
12·07	1			1·26	,,	76·2
4582·90	4	4583 (4)		,,	,,	21814·2
24·82	4			1·24	6·1	22094·2
* 02·56	9	? 4505 (2)	4502·43 (4)	1·23	,,	22203·5
01·13	7			,,	,,	10·5
*4463·88	10	4464 (3)	4463·82 (5)	1·22	6·2	22395·8
* 54·12	10	4454 (1)	4454·07 (4)	,,	,,	22438·9
25·32	1			1·21	6·3	22590·9
18·89	1			,,	,,	22623·8
10·49	1			,,	,,	66·9
00·11	6	4400 (1)	4400·05 (1)	,,	,,	22720·4
4385·87	1			1·20	,,	94·1
84·01	1			,,	,,	22803·9
* 76·33	10	4376 (3)	4376·24 (3)	,,	,,	43·9
64·58	1			,,	6·4	22905·3
* 62·83	9	4363 (2)	4362·76 (2)	,,	,,	14·5
58·43	1			,,	,,	37·6
* 55·67	1	4356 (12)	4355·62 (5)	1·19	,,	52·2
51·48	3			,,	,,	74·3
* 19·76	10	4320 (8)	4319·760 (4)	,,	,,	23143·2
* 18·74	8	4319 (3)	4318·70 (2)	1·18	,,	48·5
* 00·67	1	4301 (7)		,,	6·5	23245·7
4286·64	1			,,	,,	23321·8
* 83·17	4	4283 (3)		,,	,,	40·7
74·15	10	4274 (4)	4274·09 (4)	1·17	,,	90·0
4046·60	1			1·11	7·0	24705·1
3800·71	2			1·05	7·4	26303·5
3797·05	1			,,	,,	28·8
73·59	3			1·04	,,	26492·6
3679·58	4			1·02	7·7	27169·3
* 68·74	2			,,	,,	27249·6
65·43	3			,,	,,	74·2
50·21	2			1·01	,,	27388·0
15·57	2			,,	7·8	27650·4
3522·79	1			0·98	8·0	28378·6
02·69	2			,,	8·1	28541·4

* Visible in the second Krypton spectrum.

Second Krypton Spectrum, with Leyden Jar and Spark Gap.

*** The figures in parentheses indicate the intensities.

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda+$	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
†5871·12	1	5871 (10)		1·60	4·6	17027·9
5771·60	1	5771 (2)		1·57	4·7	17321·5
53·19	1	5753 (2)		,,	,,	77·0
5690·56	3	5690 (5)		1·55	4·8	17568·2
82·15	5	5682 (5)		,,	,,	94·2
74·70	1			,,	,,	17617·3
72·94	1			,,	,,	22·6
50·56	1 }	5650 (1)		1·54	,,	92·6
49·76	1 }			,,	,,	95·1
33·17	6	5632 (2)		,,	,,	17747·2
5597·47	1			1·53	4·9	17860·3
† 80·64	1			1·52	,,	17914·2
† 70·50	3	5571 (10)	5570·417	,,	,,	46·8
68·84	2			,,	,,	52·2
†‡ 62·45	2	5563 (3)	5562·363	,,	,,	72·8
53·15	1n	5553 (1)		,,	,,	18002·9
		5544 (not seen)				
23·75	1 }	5523 (2)		1·51	,,	99·1
23·13	2 }			,,	,,	18100·8
† 20·74	1			,,	,,	08·6
		5506 (not seen)				
5499·73	1	5500 (2)		1·50	5·0	77·7
		5483 (not seen)				
68·31	2n			1·49	,,	82·2
46·51	2	5446 (2)		,,	,,	18355·4
38·84	1	{ 5429 (not seen) 5424 (not seen)		1·48	,,	81·3
18·55	1	5403 (not seen)		,,	,,	18450·1
5333·55	2			1·46	5·1	18744·1
23·15	1			1·45	,,	80·8
17·56	1	5319 (1)		,,	,,	18800·6
08·84	1	5305 (not seen)	5208·57 (1)	,,	,,	31·4
5276·69	1	5278 (1)		1·44	,,	18946·2
29·67	1	5229 (1)		1·43	5·2	19116·5
24·72	1			,,	,,	34·3
17·59	1	5218 (1)		,,	,,	60·7
		5215 (not seen)				
08·50	3	5209 (5)	5208·57	1·42	5·3	94·1
00·36	1	5203 (1)		,,	,,	19224·1
5187·17	1	5186 (1)		,,	,,	73·0
68·33	1	5172 (not seen)		1·41	,,	19343·3
66·95	1	5166 (5)		,,	,,	48·5

† First Krypton spectrum.

‡ *Cf.* Xenon II. 5562·46 (2).

SECOND KRYPTON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda+$	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
‡5143·25	1	5143 (4)		1·41	5·3	19437·7
25·88	2	5126 (6)		1·40	,,	19507·4
23·35	1			,,	,,	13·2
5086·67	1	5087 (3)		1·39	5·4	19653·8
77·37	1	5078 (1)		,,	,,	89·8
72·71	1	5073 (2)		,,	,,	19707·9
65·74	1			,,	,,	35·1
54·61	1	5057 (not seen)		1·38	,,	78·5
46·51	1			,,	,,	19810·3
33·95	1	5034 (1)		,,	,,	59·7
28·48	1			,,	5·5	81·2
22·57	2	5023 (4)		1·37	,,	19904·6
22·01	1			,,	,,	06·8
16·58	1			,,	,,	28·4
13·42	3	5014 (2)		,,	,,	41·0
09·49	1			,,	,,	56·6
4982·95	1			1·36	,,	20062·9
79·00	3	4980 (1)		,,	,,	78·8
60·44	1	4960 (1)		,,	,,	20154·0
48·67	1			1·35	,,	97·9
45·75	2	4946 (1)		,,	,,	20213·9
33·32	1			,,	5·6	64·7
16·11	1	4903 (not seen)		1·34	,,	20335·7
4889·16	1			,,	,,	20447·8
70·23	1			1·33	,,	20527·3
‡ 57·36	1			,,	5·7	81·6
46·76	4n	4847 (2)		,,	,,	20626·6
45·79	1	4845 (2)		,,	,,	30·8
36·75	2			1·32	,,	69·3
33·89	1			,,	,,	81·6
32·26	4n	4833 (5)	4832·22 (2)	,,	,,	88·5
26·21	1			,,	,,	20714·5
25·37	3n	4826 (3)	4825·38 (1)	,,	,,	18·1
11·91	4	4812 (3)		,,	,,	76·1
03·16	<1			1·31	,,	20813·9
4796·48	2n			,,	,,	42·9
89·89	1			,,	,,	71·6
88·93	<1			,,	,,	76·8
78·57	1n			,,	,,	20921·0
73·16	2			,,	5·8	44·7
65·90	6	4766 (10)		1·30	,,	76·6
62·60	5	4763 (3)	4762·66 (2)	,,	,,	91·1
54·63	2			,,	,,	21026·3
52·14	3n			,,	,,	37·3
39·16	7	4739 (10)	4739·13 (5)	,,	,,	95·0
29·88	1			1·29	,,	21136·4
27·81	1			,,	,,	45·6
10·68	1			,,	,,	21222·6
4699·82	2		4702·73 (not seen)	,,	5·9	71·5
95·82	2			,,	,,	89·6

‡ *Cf.* Xenon II. 5143·24 (1), 4857·37 (1).

SECOND KRYPTON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
4694·59	4	4694 (3)	? 4694·82 (2)	1·29	5·9	21295·2
93·83	1			,,	,,	98·7
91·46	2			1·28	,,	21309·4
89·95	1			,,	,,	16·3
87·46	1			,,	,,	27·6
86·43	1			,,	,,	32·3
80·57	4	4680 (5)	4680·67 (3)	,,	,,	59·0
73·96	1			,,	,,	89·2
72·22	< 1			,,	,,	97·2
59·04	5	4659 (8)		,,	,,	21461·7
55·94	< 1			,,	,,	72·0
50·33	2	4650 (1)		1·27	,,	97·9
38·53	2			,,	,,	21552·6
34·05	5	4635 (6)	4634·07 (4)	,,	6·0	73·4
21·58	1			,,	,,	21631·6
20·21	< 1			,,	,,	38·0
19·31	6	4620 (8)	4619·30 (5)	,,	,,	42·2
15·46	5	4615	4615·48 (4)	1·26	,,	60·3
14·67	2			,,	,,	64·0
13·93	1			,,	,,	67·3
10·79	3	4610 (3)		,,	,,	82·3
07·03	< 1			,,	,,	21700·0
04·16	2			,,	,,	13·5
4598·64	2	4598 (1)		,,	,,	39·6
92·94	3n	4593 (2)		,,	,,	66·5
83·03	4	4583 (4)		,,	,,	21813·6
* 77·40	6	4577 (8)	4577·31 (4)	1·25	,,	40·5
75·87	1			,,	,,	47·8
73·52	2			,,	,,	59·0
56·77	4			,,	6·1	21939·3
37·45	1			1·24	,,	22032·7
36·67	1n			,,	,,	36·5
23·32	5	4525 (3)		,,	,,	22101·5
18·82	1			,,	,,	23·6
† 02·56	1	? 4505 (2)		1·23	,,	22203·5
4490·04	4	4490 (2)		,,	6·2	65·3
75·18	7	4475 (6)		,,	,,	22339·3
† 63·88	1	4464 (3)	4464·11 (not seen)	1·22	,,	95·8
60·18	1			,,	,,	22414·4
57·42	2			,,	,,	28·3
54·55	1			,,	,,	42·8
† 54·12	1	4454 (1)		,,	,,	44·9
53·38	3			,,	,,	48·7
43·87	1			,,	,,	96·7
43·46	2			,,	,,	98·8
36·98	4	4437 (6)	4436·96 (2)	,,	,,	22531·6
31·85	4	4432 (6)		,,	,,	57·7
22·86	4	4423 (2)		1·21	6·3	22603·5
17·40	2			,,	,,	31·4
‡§ 08·10	2			,,	,,	79·2

* *Cf.* Xenon II. 4577·36 (6).
† First Krypton spectrum.
‡ Visible in the spectrum of atmospheric Argon.
§ 4408·095, Kayser in the blue Argon spectrum (1).

SECOND KRYPTON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
4404·47	1			1·21	6·3	22697·9
00·98	1			,,	,,	22715·9
4399·57	1	4400 (1)		,,	,,	23·2
89·87	1			1·20	,,	73·4
86·69	4	4387 (3)		,,	,,	89·9
85·39	1			,,	,,	96·7
81·71	3			,,	,,	22815·8
77·89	2			,,	,,	36·1
* 76·33	1n	4376 (3)	4376·24	,,	,,	43·9
76·20	1			,,	,,	44·6
69·86	4			,,	,,	77·7
67·27	< 1			,,	6·4	91·2
66·43	< 1			,,	,,	95·6
* 62·83	1	4363 (2)	4362·76	,,	,,	22914·5
55·84	1			1·19	,,	51·3
* 55·67	10	4356 (12)	4355·62 (5)	,,	,,	52·2
55·14	2			,,	,,	55·0
52·76	< 1			,,	,,	67·5
51·20	2n			,,	,,	75·8
44·42	1			,,	,,	23011·6
44·05	< 1			,,	,,	13·6
41·50	< 1			,,	,,	27·1
33·50	2			,,	,,	69·6
23·16	4	4323 (2)		,,	,,	23124·8
* 19·76	1	4320 (8)	4319·760	,,	,,	43·0
19·30	1	4319 (3)		1·18	,,	45·5
* 18·74	1	4318 (3)	4318·70	,,	,,	48·5
17·98	5	4318 (3)	4318·22 (2)	,,	,,	52·6
05·37	2			,,	6·5	23220·3
01·71	3 }	4301 (7)				
* 00·67	5 }			,,	,,	40·1
4295·35	1			,,	,,	45·7
94·99	2			,,	,,	76·4
93·10	6	4293 (10)	4293·10 (5)	,,	,,	86·7
* 83·17	2	4283 (3)		,,	,,	23340·7
81·65	< 1			,,	,,	49·0
80·77	1n			1·17	,,	53·8
* 74·15	2	4274 (4)	4274·09	,,	,,	90·0
73·65	< 1			,,	,,	92·7
68·97	3 }	4269 (3)		,,	,,	23418·3
68·72	2 }			,,	,,	19·7
59·60	3	4260 (1)		,,	,,	69·9
54·98	3	4256 (1)		,,	,,	95·4
52·87	2			,,	6·6	23506·9
50·76	4	4251 (5)		,,	,,	18·6
44·32	1			,,	,,	54·3
37·11	2 }	4237 (4)		1·16	,,	94·4
36·81	3 }			,,	,,	96·1
†‡ 28·98	1			,,	,,	23619·8
26·75	3			,,	,,	52·2
26·09	3			,,	,,	55·9
25·50	1			,,	,,	59·8

* First Krypton spectrum.
† Visible in the spectrum of atmospheric Argon.
‡ 4229·015, Kayser in the blue Argon spectrum (1).

SECOND KRYPTON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
4223·22	<1			1·16	6·6	23672·1
22·36	1			,,	,,	76·8
01·84	1			1·15	,,	92·7
01·55	<1			,,	,,	94·1
4185·29	2n	4185 (3)		,,	,,	23786·6
79·67	2n			,,	,,	23918·7
72·63	2			,,	,,	59·1
71·97	2	4172 (1)		,,	,,	62·9
60·37	1			1·14	6·7	24029·6
59·13	1			,,	,,	36·8
54·62	4			,,	,,	62·9
45·28	6	4145 (8)	4145·27 (3)	,,	6·8	24116·6
39·28	4n	4140 (2)		,,	,,	52·0
38·12	4			,,	,,	58·8
34·72	3			,,	,,	78·6
33·81	<1			,,	,,	84·0
31·48	4			,,	,,	97·6
18·28	2n	4119 (3)		1·13	,,	24275·2
13·90	1			,,	,,	24301·0
09·38	6	4109 (6)		,,	,,	27·8
4098·89	7	4099 (8)		,,	6·9	89·9
88·48	8	4089 (8)	4088·53 (6)	1·12	,,	24452·1
* 82·58	4			,,	,,	87·4
69·97	4n			,,	,,	24565·3
67·53	5			,,	,,	78·0
65·22	8	4065 (7)	4065·19 (3)	,,	,,	92·0
59·02	4n	4058 (6)		,,	,,	24629·6
57·17	8	4058 (6)	4057·16 (2)	,,	,,	40·8
54·43	1			1·11	,,	63·6
50·62	5n			,,	7·0	80·6
46·30	1			,,	,,	24706·9
44·80	5	4045 (4)		,,	,,	16·1
37·96	4	4038 (2)		,,	,,	58·0
35·53	2			,,	,,	72·9
26·38	1n			,,	,,	24829·2
24·72	2n			,,	,,	39·4
08·60	2n	4008 (2)		1·10	,,	24939·4
08·21	3			,,	,,	41·8
05·70	3n	4005 (1)		,,	,,	57·4
02·73	3			,,	7·1	75·9
3998·10	5	3997 (3)		,,	,,	25004·8
96·81	<1			,,	,,	12·9
94·98	6	3994 (6)		,,	,,	24·3
92·08	2			,,	,,	42·5
90·79	2n			,,	,,	50·6
87·93	4	3988 (2)		,,	,,	68·6
87·22	1n			,,	,,	73·0
65·02	4	3965 (1)		1·09	,,	25213·5
62·46	1			,,	,,	29·7
57·82	4			,,	,,	59·3
54·90	5	3955 (2)		,,	7·2	77·9
53·71	3			,,	,,	85·7

* A line occurs in the blue spectrum of Argon of wave-length 4082·535 (Kayser), which does not disappear on fractionation (2).

SECOND KRYPTON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3952·16	3n			1·09	7·2	25295·4
47·76	1			,,	,,	25323·5
45·60	1			,,	,,	37·5
42·78	2n			,,	,,	55·6
* 42·28	1			,,	,,	58·8
41·03	1n			,,	,,	66·9
38·98	2	3939 (1)		,,	,,	80·1
38·62	1			,,	,,	82·4
34·29	3n			1·08	,,	25410·3
32·80	4n	?		,,	,,	20·0
29·34	3n	3928 (3)		,,	,,	42·4
24·91	1n			,,	,,	71·1
21·81	2n			,,	,,	91·4
20·29	8	3921 (8)	3920·59 (1)	,,	,,	25501·1
17·76	6	3918 (2)		,,	,,	17·6
17·03	1			,,	,,	22·3
14·04	1			,,	,,	41·8
13·01	1			,,	,,	48·6
12·69	5	3913 (6)	3912·36 (1)	,,	,,	50·7
06·37	8	3907 (6)		,,	7·3	91·9
01·28	2	3901 (1)		,,	,,	25625·6
3898·83	3			,,	,,	41·4
94·83	5	3896 (3)		1·07	,,	67·7
84·04	1			,,	,,	25739·1
83·77	1			,,	,,	40·9
75·95	2 }	3876 (7)		{ ,,	,,	92·8
75·56	7 }			{ ,,	,,	95·4
74·15	2			,,	,,	25804·8
73·38	2n			,,	,,	09·9
63·99	5n	3862 (1)		,,	,,	72·7
60·58	5	3859 (1)		,,	,,	95·5
58·90	2n	3859 (1)		,,	,,	25906·8
57·44	3			,,	,,	16·6
50·23	2n			1·06	,,	65·2
47·93	1n			,,	,,	70·7
47·63	1			,,	,,	82·7
46·99	1	3847 (1)		,,	,,	87·1
44·55	2n	3844 (2)		,,	,,	26003·5
42·98	1n			,,	,,	14·1
42·40	3	3842 (1)		,,	,,	18·1
39·49	1	3839 (1)		,,	,,	37·8
36·64	3	3837 (2)		,,	,,	57·2
35·47	1			,,	,,	65·1
35·10	2n			,,	,,	67·6
21·93	1n			,,	,,	26157·5
17·23	3	3817 (2)		,,	7·4	89·7
14·70	2n			1·05	,,	26207·0
09·30	2			,,	,,	44·1
06·46	1 }	3806 (2)		{ ,,	,,	63·7
06·28	1 }			{ ,,	,,	65·0
04·80	4	3805 (3)		,,	,,	75·2
3793·35	1			,,	,,	26354·5
92·82	4			,,	,,	58·2

* *Cf.* Xenon II. 3942·29 (1).

SECOND KRYPTON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3791·22	2n			1·05	7·4	26369·3
88·26	2n			,,	,,	89·9
85·76	1n			,,	,,	26407·4
83·28	10	3784 (10)	3783·40 (4)	,,	,,	24·7
80·70	1			,,	,,	42·7
78·23	10	3779 (8)	3778·29 (4)	,,	,,	60·0
76·66	1n			1·04	,,	71·0
75·68	1			,,	,,	77·9
73·20	2			,,	,,	95·3
71·46	4	3772 (4)		,,	7·5	26507·4
* 68·10	1n			,,	,,	31·1
* 65·98	1n			,,	,,	46·0
59·04	2n	3759 (2)		,,	,,	95·0
55·92	1n			,,	,,	26617·1
54·35	5	3755 (6)		,,	,,	28·3
† 51·81	1			,,	,,	46·2
49·77	3n			,,	,,	60·8
44·95	9	3746 (6)		,,	,,	95·1
41·83	10	3742 (6)	3741·85 (3)	,,	,,	26717·4
40·87	2			,,	,,	24·2
40·37	1			,,	,,	27·8
35·91	5	3736 (3)		1·03	,,	59·7
‡ 33·09	2 }	3734 (4)		{ ,,	,,	80·0
32·77	3 }			,,	,,	82·3
31·82	1			,,	,,	89·1
28·13	2n			,,	7·6	26815·5
26·45	2			,,	,,	27·4
21·50	7	3722 (5)		,,	,,	63·3
18·79	8 }	3719 (10)		{ ,,	,,	82·9
18·17	10 }			,,	,,	87·3
16·28	1			,,	,,	26901·0
15·18	3	3715 (1)		,,	,,	09·0
08·23	1n			,,	,,	59·4
3696·84	1			1·02	,,	27042·5
90·80	5	3691 (1)		,,	,,	86·8
86·30	6	3687 (5)	3686·26 (1)	,,	,,	27119·9
80·64	1 }	3681 (7)		{ ,,	,,	61·3
80·52	7 }			,,	7·7	62·4
78·77	2			,,	,,	75·3
74·37	1			,,	,,	27207·8
70·38	1			,,	,,	37·4
69·16	9	3670 (7)		,,	,,	46·4
§ 68·74	2 }	3667 (1)		{ ,,	,,	49·6
66·15	3 }			,,	,,	68·9
63·57	4	3664 (3)		,,	,,	88·1
61·15	4	3661 (3)		,,	,,	27306·1
60·20	1			,,	,,	13·2
54·11	10	3654 (10)	3654·11 (3)	1·01	,,	58·7
48·74	5	3649 (3)		,,	,,	99·0
44·36	1			,,	,,	27431·9
41·48	4			,,	,,	53·7

* *Cf.* Xenon II. 3768·08 (1), 3765·99 (4). † *Cf.* Xenon II. 3751·80 (1).
‡ 3733·122 (1) in blue spectrum of Argon (Kayser).
§ First Krypton spectrum.

SECOND KRYPTON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum		Oscillation Frequency in Vacuo
				$\lambda +$	$\frac{1}{\lambda} -$	
3637·63	4	3638 (4)		1·01	7·8	27482·6
34·54	2n			,,	,,	27506·0
33·69	2			,,	,,	12·4
32·62	1			,,	,,	20·5
32·02	10	3632 (10)		,,	,,	25·1
27·20	1			,,	,,	61·7
23·74	4	3624 (1)		,,	,,	88·0
15·97	3			1·00	,,	27647·3
11·21	1			,,	,,	83·7
08·02	9	3608 (6)		,,	,,	27708·2
04·10	1			,,	,,	38·4
02·26	1n			,,	,,	52·5
00·05	6	3600 (6)		,,	,,	69·6
3599·35	4			,,	,,	75·0
98·14	1			,,	,,	84·3
96·99	1			,,	,,	93·2
89·79	7	3590 (3)		,,	7·9	27848·9
86·40	2			,,	,,	75·2
80·11	1			,,	,,	27924·2
77·74	1			0·99	,,	42·7
72·82	3n	3574 (1)		,,	,,	81·2
67·88	2			,,	,,	28019·9
* 64·38	4			,,	,,	47·5
63·48	1			,,	,,	54·6
62·23	1			,,	,,	64·4
55·69	2n			,,	,,	28116·0
53·61	4	3554 (2)		,,	,,	32·5
49·57	3			,,	8·0	64·4
48·86	2			,,	,,	70·1
44·69	5 }	3545 (6)		,,	,,	28203·2
44·29	5 }			,,	,,	06·7
† 35·48	6			0·98	,,	76·7
27·53	1			,,	,,	28340·4
24·93	1			,,	,,	61·4
21·27	1			,,	,,	90·8
17·52	1			,,	,,	28421·1
14·68	3			,,	,,	44·9
07·58	9			,,	8·1	28501·6
03·38	6	3503 (2)		,,	,,	35·8
3498·63	1n			0·97	,,	74·5
97·29	3			,,	,,	85·5
93·16	2			,,	,,	28619·3
92·94	2			,,	,,	21·1
88·74	8	3489 (2)		,,	,,	55·5
87·61	1			,,	,,	64·8
78·04	1			,,	,,	28743·7
74·79	7			,,	,,	70·6
71·52	< 1			,,	,,	97·7
71·16	1			,,	,,	28800·7
70·19	7	3470 (1)		,,	8·2	08·7
65·54	1n			,,	,,	47·3
60·24	6	3460 (3)		,,	,,	91·5
48·87	4			0·96	,,	28986·8

* *Cf.* Xenon II. 3564·40 (4).

† *Cf.* Argon 3535·514 (4) Kayser.

SECOND KRYPTON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3447·01	3			0·96	8·2	20902·4
46·66	7n			,,	,,	05·4
45·43	1			,,	,,	15·8
43·01	1			,,	,,	36·2
39·60	6			,,	,,	65·0
39·03	1			,,	,,	69·8
31·85	1			,,	8·3	29130·1
31·15	2			,,	,,	38·4
* 28·95	1			,,	,,	55·1
27·84	4			,,	,,	64·6
23·87	3			,,	,,	98·4
14·95	1			0·95	,,	29274·7
05·28	7			,,	,,	29357·8
* 3396·72	2			,,	,,	29431·9
89·80	1			,,	8·4	91·9
89·06	3			,,	,,	98·3
* 87·26	1			,,	,,	29514·0
85·35	1			,,	,,	30·6
† 81·24	2			,,	,,	66·5
* 79·18	1			,,	,,	84·6
75·09	4			0·94	,,	29620·4
* 60·22	2			,,	8·5	29751·5
52·07	6			,,	,,	29823·8
49·61	3n			,,	,,	45·7
48·28	2			,,	,,	57·6
42·59	5			,,	,,	29908·4
41·70	1n			,,	,,	16·4
40·61	2n			,,	,,	26·1
37·99	1n			0·93	,,	49·6
36·84	1n			,,	,,	60·0
32·61	3			,,	,,	98·0
* 30·88	7			,,	,,	30013·6
29·86	1n			,,	,,	22·8
28·34	1n			,,	,,	36·5
25·84	9			,,	,,	59·1
24·23	1n			,,	8·6	72·6
21·26	1			,,	,,	30100·4
20·39	1n			,,	,,	08·3
19·48	1			,,	,,	16·6
* 15·80	1			,,	,,	50·0
11·59	6			,,	,,	88·4
08·28	4			,,	,,	30216·6
05·79	1n			,,	,,	41·3
04·87	5			,,	,,	49·7
01·97	1			,,	,,	76·2
3294·02	1			0·92	,,	30349·5
86·01	4			,,	8·7	30423·3
85·30	1			,,	,,	29·4
82·21	1			,,	,,	58·6
71·77	4			,,	,,	30555·8

* *Cf.* Xenon II., 3428·95 (1), 3396·72 (2), 3387·26 (1), 3379·20 (2), 3360·20 (2), 3330·90 (6), 3315·80 (1).

† A line is given by Eder and Valenta in the blue Argon spectrum at 3381·27. This line was not seen by Kayser nor Baly.

SECOND KRYPTON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3268·61	7			0·92	8·7	30585·3
64·94	8			,,	,,	30619·7
61·70	1n			,,	,,	50·2
48·16	1n			0·91	8·8	30777·9
47·14	1n			,,	,,	87·5
46·74	2			,,	,,	91·3
45·82	10			,,	,,	30800·1
40·55	6			,,	,,	50·2
39·64	6			,,	,,	58·8
37·94	1			,,	,,	85·0
35·29	1			,,	,,	30900·3
24·99	3			,,	,,	99·0
23·66	1n			,,	,,	31011·8
* 22·40	1			,,	,,	24·0
20·76	4			0·90	,,	39·8
16·39	1			,,	,,	82·0
11·04	1			,,	8·9	31133·7
08·39	3			,,	,,	59·4
07·91	4			,,	,,	64·0
05·40	1n			,,	,,	88·4
02·67	1n			,,	,,	31215·0
00·53	3			,,	,,	35·9
3191·33	6			,,	,,	31326·0
89·23	7			,,	,,	46·6
77·09	1n			0·89	9·0	31466·3
* 75·78	2n			,,	,,	79·3
71·06	3			,,	,,	31526·2
51·88	3			,,	,,	31718·1
51·06	5			,,	,,	26·3
44·90	1			,,	9·1	88·4
44·47	2			,,	,,	92·8
42·01	5			,,	,,	31817·7
41·48	6			0·88	,,	23·0
39·71	3			,,	,,	41·0
* 38·49	1			,,	,,	53·4
36·33	2			,,	,,	75·3
35·24	1			,,	,,	86·4
24·52	6			,,	,,	95·8
22·61	3			,,	,,	32015·4
20·73	4			,,	,,	34·7
12·36	5			,,	9·2	32120·8
05·48	1			,,	,,	91·9
01·85	1			0·87	,,	32229·6
3097·27	4			,,	,,	77·3
96·59	3n			,,	,,	84·4
95·24	1n			,,	,,	98·5
63·26	5			,,	9·3	32635·7
62·55	1			0·86	,,	43·2
60·99	2n			,,	,,	59·8
56·86	4			,,	,,	32704·0
56·14	2			,,	,,	11·7
49·83	2			,,	9·4	78·3
47·07	5			,,	,,	32809·0

* *Cf.* Xenon II. 3222·40 (1), 3175·80 (3), 3138·46 (6).

SECOND KRYPTON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
*3044·92	1			0·86	9·5	32832·2
24·57	4			0·85	,,	33057·0
22·43	3			,,	,,	76·3
17·78	2n			,,	,,	33127·4
13·36	1			,,	,,	76·0
08·57	2			,,	,,	33224·9
02 39	1			,,	,,	97·3
2999·99	3n			,,	,,	33323·9
96·77	2			,,	9·6	59·6
92·36	3			,,	,,	33408·8
86·02	1			,,	,,	79·8
83·22	1			,,	,,	33511·2
79·95	3			0·84	,,	48·0
79·01	3			,,	,,	58·6
76·44	1			,,	,,	87·6
76·06	1			,,	,,	91·9
74·18	3			,,	,,	33613·1
71·90	1			,,	,,	38·9
68·44	2			,,	9·7	78·0
67·37	5			,,	,,	90·2
63·26	1			,,	,,	33736·9
61·19	2			,,	,,	60·5
* 60·92	2			,,	,,	63·6
60·27	3n			,,	,,	71·0
58·48	2n			,,	,,	91·4
56·44	1			,,	,,	33814·8
54·40	2			,,	,,	38·1
52·69	4			,,	,,	57·7
52·23	1			,,	,,	63·0
50·33	3			,,	,,	84·8
49·67	2			,,	,,	92·4
48·27	1			,,	,,	33908·5
40·05	1			0·83	9·8	34003·2
38·70	1			,,	,,	38·8
35·36	2			,,	,,	46·0
34·13	1			,,	,,	71·8
31·03	1			,,	,,	34107·9
30·72	1			,,	,,	11·5
27·69	1			,,	,,	46·8
17·81	1			,,	9·9	34262·4
15·88	1			,,	,,	85·1
15·40	1			,,	,,	90·7
13·35	1			,,	,,	34314·8
09·30	2			,,	,,	62·6
08·74	1			,,	,,	69·2
00·19	3			0·82	,,	34470·6
2893·81	4			,,	10·0	34546·5
92·30	5			,,	,,	64·6
73·84	1			,,	,,	34786·6
72·99	1			,,	,,	96·9
70·73	4			,,	10·1	34824·2
51·29	3			0·81	,,	35061·7
47·51	4			,,	10·2	35108·2

* *Cf.* Xenon II. 3044·91 (1), 2960·93 (2).

SECOND KRYPTON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
*2844·59	3			0·81	10·2	35144·2
* 41·10	1			,,	,,	87·4
38·92	3			,,	,,	35214·5
36·08	1			,,	,,	49·7
35·49	2n			,,	,,	57·1
33·11	6			,,	,,	86·7
30·55	1n			,,	,,	35318·6
29·60	1			,,	,,	30·5
22·75	1			0·80	10·3	35416·1
17·00	4			,,	,,	88·5
16·58	6			,,	,,	93·7
* 14·62	2			,,	,,	35518·5
14·09	1			,,	,,	25·2
* 11·81	2			,,	,,	54·0
06·21	1			,,	,,	35625·0
03·71	1			,,	,,	56·7
03·32	4			,,	,,	61·7
01·25	1n			,,	,,	87·9
2795·92	5			,,	10·4	35756·0
90·31	1			,,	,,	35827·9
79·63	1			0·79	,,	65·6
79·23	3			,,	,,	70·8
78·34	1			,,	,,	82·3
74·70	1			,,	10·5	36029·4
72·73	2			,,	,,	55·0
61·87	1			,,	,,	36196·9
59·16	1n			,,	,,	36232·4
* 56·66	1			,,	,,	65·3
52·33	1			,,	,,	36322·3
51·71	1n			,,	,,	30·5
50·49	1			,,	10·6	46·6
48·18	1			,,	,,	77·1
42·67	4			,,	,,	36450·1
42·13	1			,,	,,	57·4
* 33·38	4			0·78	,,	36574·1
* 32·46	1			,,	,,	86·4
30·55	1			,,	,,	36612·0
30·02	1			,,	,,	29·2
29·58	4			,,	,,	55·1
20·03	1n			,,	10·7	36753·6
16·27	3			,,	,,	36804·5
15·31	1			,,	,,	17·5
14·61	1			,,	,,	27·0
12·50	8			,,	,,	55·7
11·22	1			,,	,,	73·2
10·37	1			,,	,,	84·6
01·45	3			,,	10·8	37006·4
00·73	1			,,	,,	16·2
2698·20	1			0·77	,,	50·9
97·41	4			,,	,,	61·8
† 96·71	4			,,	,,	71·4
95·81	4			,,	,,	83·8

* *Cf.* Xenon II. 2844·59 (3), 2841·10 (1), 2814·62 (6), 2811·81 (3), 2756·64 (1), 2733·36 (4), 2732·48 (1).

† *Cf.* Xenon II. 2696·73 (4).

SECOND KRYPTON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda+$	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
2694·93	3			0·77	10·8	37095·9
92·65	1			,,	,,	37127·3
* 91·94	1			,,	,,	37·1
91·31	1			,,	,,	45·8
* 90·35	1			,,	,,	59·1
88·44	1			,,	,,	85·5
83·66	3			,,	,,	37250·6
81·29	4			,,	,,	84·7
80·80	1			,,	,,	91·5
80·44	3			,,	,,	96·5
79·73	2			,,	,,	37306·4
* 77·30	2			,,	10·9	40·2
76·10	1			,,	,,	56·9
75·41	1			,,	,,	66·5
* 70·78	2			,,	,,	37431·3
64·10	2n			,,	,,	37525·2
61·34	1			,,	,,	65·4
61·09	2n			,,	,,	67·7
56·49	2n			,,	,,	37632·8
54·07	1			0·76	11·0	67·0
49·84	1n			,,	,,	37727·1
49·38	3			,,	,,	33·7
* 48·80	1			,,	,,	41·9
48·55	1			,,	,,	45·5
48·26	4			,,	,,	49·6
43·18	3			,,	,,	37822·2
42·19	1			,,	,,	36·4
40·84	1			,,	,,	55·6
39·86	4			,,	,,	69·8
34·52	1			,,	,,	37946·6
30·76	2			,,	11·1	38000·7
29·00	3			,,	,,	26·2
28·19	1			,,	,,	37·9
27·86	2			,,	,,	42·7
27·34	1			,,	,,	50·2
24·90	1n			,,	,,	85·6
† 24·63	1			,,	,,	89·5
20·54	4			,,	,,	38149·1
† 16·80	2			,,	,,	38203·5
11·08	3			,,	,,	87·1
04·72	1			0·75	11·2	38380·5
04·59	1			,,	,,	82·6
02·23	2			,,	,,	38417·4
2597·80	2			,,	,,	82·9
96·83	1n			,,	,,	97·3
95·44	1n			,,	,,	38517·9
94·49	1			,,	,,	32·0
92·57	5			,,	,,	60·6
91·33	1			,,	,,	79·0
90·83	1			,,	,,	86·5
89·19	4			,,	,,	38610·9
84·21	1			,,	11·3	85·2

* *Cf.* Xenon II. 2691·92 (1), 2690·33 (1), 2677·29 (8), 2670·80 (2), 2648·79 (1).
† *Cf.* Xenon II. 2624·65 (1), 2616·79 (1).

SECOND KRYPTON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
*2581·84	1n			0·75	11·3	38720·8
74·87	1			,,	,,	38825·6
* 72·44	1			,,	,,	62·3
72·14	2			,,	,,	66·8
71·30	1			,,	,,	79·5
70·54	1			,,	,,	91·0
65·72	1			,,	11·4	38964·0
63·32	2			0·74	,,	39002·0
62·05	1			,,	,,	19·8
59·20	2			,,	,,	63·3
58·08	1			,,	,,	80·4
56·44	2			,,	,,	39105·5
56·01	2			,,	,,	12·1
55·23	2			,,	,,	24·1
54·35	2			,,	,,	37·5
53·26	1			,,	,,	54·2
48·68	1			,,	11·5	39224·5
44·79	1			,,	,,	84·5
38·43	2n			,,	,,	39382·9
37·67	1			,,	,,	94·7
35·97	1			,,	,,	39421·1
28·51	1			,,	11·6	39537·4
27·26	2n			,,	,,	57·0
25·56	1n			,,	,,	83·5
25·07	2			,,	,,	91·3
19·38	1			,,	,,	39680·7
18·02	1			,,	,,	39702·1
15·50	1			0·73	,,	41·9
* 13·50	1			,,	,,	73·6
13·03	1			,,	,,	81·0
11·83	1			,,	11·7	99·9
06·97	1			,,	,,	39877·1
06·66	2n			,,	,,	82·0
03·97	3n			,,	,,	39924·6
00·72	1			,,	,,	76·8
2498·84	1			,,	,,	40006·9
97·81	1			,,	,,	23·4
97·51	1n			,,	,,	28·2
† 94·10	2			,,	,,	82·9
89·51	3			,,	11·8	40156·9
87·75	2			,,	,,	85·2
87·58	2			,,	,,	87·9
86·40	2			,,	,,	40207·0
85·68	2			,,	,,	18·6
83·71	2			,,	,,	50·5
83·32	2			,,	,,	56·9
83·09	1			,,	,,	70·7
78·97	4			,,	,,	40327·5
74·99	2			,,	11·9	92·3
74·79	2			,,	,,	95·6
74·06	1			,,	,,	40407·5
73·39	1			,,	,,	18·4
72·24	1			,,	,,	37·2

* *Cf.* Xenon II. 2581·84 (1), 2572·46 (2), 2513·52 (1).
† *Cf.* Xenon II. 2494·11 (3).

SECOND KRYPTON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum λ+	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
? 2470·50	2			0·73	11·9	40465·7
* 68·56	2			0·72	,,	97·5
67·00	2			,,	,,	40523·2
65·91	2			,,	,,	40·1
64·87	8			,,	,,	58·2
59·74	1			,,	12·0	40642·7
57·79	2			,,	,,	75·0
56·16	6			,,	,,	40701·9
55·42	1			,,	,,	14·2
54·19	1			,,	,,	34·6
53·37	2			,,	,,	48·3
52·38	3			,,	,,	64·7
46·56	2			,,	,,	40861·9
42·68	1			,,	12·1	40926·5
40·96	1			,,	,,	55·4
39·64	1			,,	,,	77·6
39·32	2			,,	,,	82·9
28·44	3			,,	,,	41166·6
26·46	3			,,	12·2	99·8
* 25·15	1n			,,	,,	41224·3
20·30	1			0·71	,,	41305·0
18·13	1			,,	,,	42·1
&c.						

* *Cf.* Xenon II. 2468·54 (2), 2425·18 (2).

FIRST XENON SPECTRUM, WITHOUT LEYDEN JAR AND SPARK GAP.

*** The figures in parentheses indicate the intensities.

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum λ+	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
6198·70	1			1·69	4·4	16128·0
82·92	3	6183 (1)		1·68	,,	69·2
80·16	1	6181 (1)		,,	,,	76·4
78·80	2			,,	,,	80·0
64·30	2	? 6166 (1)		,,	,,	16218·0
12·58	1	5935 (1) (not seen)		1·67	,,	16355·3
5895·20	1	5895 (1)		1·61	4·6	16958·3
75·30	1	5876 (1)		1·60	,,	17015·8
		5856 (1) (not seen)				
24·98	1	5825 (2)		1·59	4·7	17162·7
24·08	1			,,	,,	65·4
5716·20	2n			1·58	4·8	17489·3
5696·68	1			1·55	,,	17549·3
95·96	2			,,	,,	51·5
88·59	1			,,	,,	74·2

FIRST XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
5649·77	<1			1·54	4·8	17695·0
19·07	2			1·53	,,	17791·7
12·84	<1			,,	,,	17811·4
5581·96	1			1·52	4·9	17910·0
80·60	1			,,	,,	14·3
79·48	<1			,,	,,	17·9
63·83	2			,,	,,	68·3
52·59	2			1·51	,,	18004·7
5488·73	<1			1·50	5·0	18214·1
40·16	1n			1·49	,,	18376·8
5394·84	1			1·47	5·1	18531·1
92·94	2			,,	,,	37·7
63·74	<1			1·46	,,	38·6
5028·42	2	5025 (1) (not seen)		1·42	5·5	19881·5
4923·28	6	4924 (4)		1·35	5·6	20306·0
16·63	6	4917 (4)		1·34	,,	33·5
4843·44	2			1·33	5·7	20640·8
29·87	4	4820 (1)		1·32	,,	98·8
* 07·19	6	4807 (1)		,,	,,	20796·5
4792·77	1			1·31	,,	20860·1
* 34·30	8	4734 (1)		1·30	5·8	21116·6
4697·17	7	Band of close lines		1·29	5·9	21283·5
91·13	1			1·28	,,	21310·9
83·83	1			,,	,,	44·1
* 71·42	10			,,	,,	21400·9
68·32	1			,,	,,	15·0
58·94	1			,,	,,	58·2
* 24·46	15	4624 (2)		1·27	6·0	21618·2
12·06	2			1·26	,,	76·3
4582·89	5			,,	,,	21817·2
24·83	6	4525 (5)		1·24	6·1	22094·2
* 01·13	10	4500 (1)		1·23	,,	22205·6
4385·97	1	4386 (3)		1·20	6·3	22793·7
84·12	2			,,	,,	22803·3
76·35	3	4375 (4)		,,	,,	43·8
58·51	3			,,	6·4	22937·2
4203·87	2	4204 (1)		1·15	6·6	23781·0
4193·70	8	4193 (6)		,,	6·7	23938·6
93·19	1			,,	,,	41·4
35·27	1			1·14	6·8	24175·4
16·25	7			1·13	,,	24287·1
09·84	5			,,	,,	24325·0
4078·94	10	4079 (1)		1·12	6·9	24509·3
46·71	3			1·11	7·0	24704·4
3985·39	3			1·10	7·1	25084·5
74·61	3			1·09	,,	25152·6
67·74	10			,,	,,	96·2
51·16	10	3951 (6)		,,	7·2	25301·8
48·93	1			,,	,,	15·7
48·38	3			,,	,,	19·6
*3826·99	2	3826 (1)		1·06	7·3	26122·9
23·86	1			,,	,,	44·3

* Visible in the second Xenon spectrum.

FIRST XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3810·01	2			1·05	7·4	26239·2
04·96	3			,,	,,	74·1
01·54	1			,,	,,	97·7
3796·47	3			,,	,,	26332·9
73·58	1			1·04	,,	26492·6
45·54	1			,,	7·5	26691·0
3693·69	3			1·02	7·6	27065·6
86·08	3			,,	,,	27121·5
79·77	1			,,	7·7	67·9
70·10	1			,,	,,	27239·5
65·53	1			,,	,,	73·5
63·52	< 1			,,	,,	88·4
55·03	1			1·01	,,	27351·8
50·36	4			,,	,,	86·9
10·47	2			1·00	7·8	27689·4
3554·16	2			0·99	7·9	28128·1
49·99	2			,,	8·1	61·0
06·90	1			0·98	,,	28507·1
3472·48	< 1			0·97	,,	28789·8
69·95	< 1			,,	8·2	28810·7
3341·65	1			0·94	8·5	29916·8
3132·01	2			0·88	9·1	31919·2
31·66	1			,,	,,	23·9
* 25·85	2			,,	,,	82·2
3022·09	1			0·85	9·5	33080·2
2536·58	2			0·74	11·5	39420·1

* Visible in the second Xenon spectrum.

SECOND XENON SPECTRUM, WITH LEYDEN JAR AND SPARK GAP.

*** The figures in parentheses indicate the intensities.

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
6097·80	7	6097 (6)		1·66	4·4	16395·0
51·36	7	6051 (6)		1·65	4·5	16520·7
36·40	6	6036 (5)		1·64	,,	61·7
5976·67	7	5976 (6)		1·63	,,	16727·3
71·32	1	5972		,,	,,	42·2
45·71	1	5946 (2)		1·62	4·6	16814·2
		5935 (not seen)				
17·73	1			1·61	,,	93·8
05·40	1	5906 (1)		,,	,,	16929·2
5893·59	1	? 5895 (1)		,,	,,	63·0
16·21	1	5817 (1)		1·58	4·7	17188·6
5776·46	3	5777 (4)		1·57	,,	17306·4
58·92	4	5759 (4)		,,	,,	59·7

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
5754·38	1n			1·57	4·7	17373·4
52·79	1			„	„	78·2
51·28	5	5751 (5)		„	„	82·7
48·95	1			„	„	89·8
27·15	5	5727 (4)		1·56	„	17456·0
19·83	6	5720 (4)		„	4·8	78·2
16·36	1			„	„	88·8
08·74	1			„	„	17512·2
01·48	1	At 5700 (6) (not seen)		1·55	„	34·5
5699·80	1			„	„	39·7
86·73	1			„	„	80·0
75·41	1			„	„	17615·0
71·15	3			„	„	28·3
67·85	6	5668 (4)		„	„	38·6
59·67	5	5660 (1)		1·54	„	64·1
33·32	1			„	„	17746·7
25·18	1			1·53	„	72·4
19·18	1			„	„	91·4
16·99	6	5617		„	„	98·3
13·14	1			„	„	17810·5
07·18	1	5609 (1)		„	4·9	29·4
04·66	1			„	„	37·4
5595·32	2n			„	„	67·2
91·96	1			„	„	77·9
84·00	2n	5583 (1)		1·52	„	17903·4
82·30	2n			„	„	08·9
72·48	2	5573 (1)		„	„	40·4
70·60	1			„	„	46·5
53·08	1			„	„	18003·1
48·40	1			1·51	„	18·3
31·33	7	5532 (4)		„	„	73·9
25·81	2			„	„	92·0
24·63	1			„	„	95·9
18·96	1			1·50	„	18114·4
07·72	1			„	„	51·4
5495·20	1			„	5·0	92·7
81·38	3n			„	„	18238·6
72·90	7	5473 (3)		1·49	„	66·8
69·81	1			„	„	77·2
60·63	6	5461 (3)		„	„	18307·9
53·33	1			„	„	32·4
51·22	1			„	„	39·5
50·71	5	5451 (1)		„	„	41·2
45·70	2			„	„	58·1
39·19	8	5439 (3)		1·48	„	80·1
19·40	10	5420 (10)	5419·38 (as a weak krypton line)	„	„	18447·6
15·64	1			„	„	60·0
13·74	2			„	„	66·5
01·23	3			1·47	5·1	18509·2
5386·90	1			„	„	58·5
72·62	8	5372 (6)		„	„	18607·8
68·30	3	5368 (1)		„	„	22·8

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda+$	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
5367·29	1			1·47	5·1	18626·3
63·47	2			1·46	,,	39·5
39·56	9	5339 (6)		,,	,,	18723·0
28·10	1			,,	,,	63·3
14·15	8	5313 (1)		1·45	,,	18812·6
11·15	1			,,	,,	23·2
09·49	4	5309 (1)		,,	,,	29·1
5292·40	10	5292 (10)	5292·37 (as a weak krypton line)	,,	5·2	89·8
68·50	1			1·44	,,	18975·5
62·16	5	5262 (2)		,,	,,	98·4
60·65	5 }	5260 (2)		,,	,,	19003·9
60·10	1 }			,,	,,	05·8
47·98	1			1·43	,,	49·7
39·14	2	5240		,,	,,	81·9
26·84	1	5227 (1)		,,	,,	19126·8
23·85	1			,,	,,	37·8
06·52	1			1·42	5·3	19201·4
01·64	1	5202 (1)		,,	,,	19·4
5192·36	1 }	5192 (6)		,,	,,	53·8
91·60	5 }			,,	,,	56·6
88·28	4	5189 (3)		,,	,,	68·9
84·68	2	5185 (3)		,,	,,	82·3
79·02	3	5179 (3)		,,	,,	19303·4
* 43·24	1			1·41	,,	19437·7
25·94	3	5126 (3)		1·40	,,	19503·3
22·65	3	5123 (1)		,,	,,	15·9
07·58	3	5107 (3)		,,	5·4	73·3
5099·96	1			1·39	,,	19602·6
92·22	3			,,	,,	32·4
80·88	7	5080 (2)		,,	,,	76·2
		5068 (5) (not seen)				
52·74	1	5052 (1)		1·38	,,	19785·8
45·09	3	5045 (6)		,,	,,	19815·9
41·62	1			,,	,,	29·5
28·62	1	? 5025 (1)		,,	,,	80·8
13·04	1			1·37	5·5	19942·5
08·74	1			,,	,,	59·6
01·20	1			,,	,,	89·7
4994·27	1			,,	,,	20017·4
93·22	1			,,	,,	21·7
91·36	2			,,	,,	29·1
88·22	2	4988 (4)		1·36	,,	41·7
78·49	4			,,	,,	80·8
71·85	1	4972 (2)		,,	,,	20107·7
23·40	1			1·35	5·6	20306·6
21·68	6	4922 (8)		,,	,,	12·7
19·85	4			,,	,,	20·2
16·71	1			1·34	,,	33·2
4890·24	5	4890 (3)		,,	,,	20443·2
87·47	5	4887 (not given)		,,	,,	54·8

* *Cf.* Krypton II. 5143·25.

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
4884·36	1	4884 (4)		1·34	5·6	20467·9
83·68	6	4883 (not given)		,,	,,	71·2
76·68	7	4876 (4)		1·33	,,	20500·2
69·60	3			,,	,,	30·0
62·69	8			,,	,,	59·2
* 57·37	1			,,	,,	20582·1
53·90	2			,,	,,	95·4
44·50	10	4844 (10)	4844·58 (as a weak krypton line)	,,	,,	20636·4
32·16	2			1·32	,,	89·0
29·23	1	4830 (1)		,,	,,	20701·5
25·23	1			,,	,,	18·8
23·47	6	4823 (3)		,,	,,	26·4
18·15	4			,,	5·7	49·1
17·30	1			,,	,,	52·8
* 07·19	1	4807 (1)		,,	,,	96·5
4796·66	1n			1·31	,,	20842·1
94·61	2 }	4793 (1)		,,	,,	51·1
92·72	1 }			,,	,,	59·3
87·95	4	4787 (2)		,,	,,	80·1
86·83	1n			,,	,,	85·0
79·33	1	4779 (2)		,,	5·8	20917·6
75·85	1			,,	,,	32·9
75·33	1			,,	,,	35·2
73·34	2n			,,	,,	43·9
69·21	4	4769 (2)		,,	,,	62·0
57·48	1			1·30	,,	21013·7
49·10	3			,,	,,	50·8
44·04	1			,,	,,	73·3
		4740 (not seen)				
* 34·30	1	4734 (1)		,,	,,	21116·6
32·53	1			,,	,,	24·5
31·35	3n	4731 (1)		,,	,,	30·8
23·74	2	4723 (1)		1·29	,,	63·9
15·31	3 }	4714 (1)		,,	,,	21201·7
12·78	3 }			,,	,,	14·1
4698·20	5	4698 (3)		,,	5·9	78·8
93·50	< 1			,,	,,	21300·2
83·76	5			1·28	,,	44·5
77·00	1n	Band of close lines		,,	,,	75·3
76·61	3n			,,	,,	77·1
74·78	3			,,	,,	85·5
73·91	4			,,	,,	89·5
72·40	2			,,	,,	96·4
71·88	1			,,	,,	98·8
* 71·41	2			,,	,,	21400·9
68·72	3			,,	,,	13·2
66·48	2n			,,	,,	23·5
59·10	1			,,	,,	57·5

* *Cf.* first Xenon spectrum.

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
*4658·06	3			1·28	5·9	21462·3
53·23	3			1·27	,,	84·5
52·15	6	4652 (4)		,,	,,	89·5
41·64	2			,,	,,	21538·2
37·42	1			,,	,,	57·8
33·49	3	4634 (2)		,,	6·0	76·0
32·83	< 1			,,	,,	79·1
31·67	1n			,,	,,	84·5
† 24·47	2n	4624 (2)		,,	,,	21618·1
20·60	< 1			,,	,,	36·2
17·66	2n			1·26	,,	50·0
15·72	5	4616 (3)		,,	,,	59·1
03·21	10	4602 (8)		,,	,,	21718·0
00·20	1n			,,	,,	32·2
4593·90	1			,,	,,	62·0
92·22	6n	4592 (3)		,,	,,	70·0
85·65	10	4586 (5)		,,	,,	21801·2
80·81	1n			1·25	,,	24·2
† 77·36	6	4577 (3)	4577·31 (as krypton line)	,,	,,	40·7
72·16	1n			,,	,,	65·5
71·85	1n			,,	,,	67·0
69·29	1			,,	,,	79·2
56·08	3n	4556 (2)		,,	6·1	21942·1
50·90	1			,,	,,	67·6
45·34	8	4545 (3)		,,	,,	94·5
41·03	8	4541 (3)		1·24	,,	22015·3
37·51	3			,,	,,	32·4
37·02	1	4535 (2)		,,	,,	34·8
32·67	5			,,	,,	56·0
24·38	5	4525 (5)		,,	,,	96·4
21·98	3n	4522 (1)		,,	,,	22108·1
07·32	1			,,	,,	80·0
03·64	2			1·23	,,	98·2
‡ 01·14	2	4500 (1)		,,	,,	22208·5
86·12	2	4486 (1)		,,	6·2	84·8
81·01	7n	4481 (5)		,,	,,	22310·2
74·10	< 1n			,,	,,	44·7
72·12	< 1	4471 (1)		,,	,,	54·6
68·34	< 1			1·22	,,	73·5
62·38	20	4462 (10)		,,	,,	22403·4
60·75	< 1			,,	,,	11·6
53·81	3			,,	,,	46·5
48·28	10	4449 (6)		,,	,,	74·4
41·08	3n	4440 (1)		,,	,,	22510·8
34·35	6	4434 (2)		,,	,,	45·9
18·10	2			1·21	6·3	22627·9
16·21	3n	4415 (8)		,,	,,	37·5
15·00	7			,,	,,	43·8
13·23	3			,,	,,	52·8
06·99	5n	4407 (3)		,,	,,	84·9

* *Cf.* Argon blue spectrum 4658·08 (Kayser).
† *Cf.* Krypton II. 4857·36, 4577·40 (6).
‡ *Cf.* first Xenon spectrum.

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
4395·91	10	4396 (4)		1·21	6·3	22742·1
95·30	1			,,	,,	45·4
93·34	10	4393 (4)		1·20	,,	55·4
87·65	1			,,	,,	84·9
86·19	1	4386 (3)		,,	,,	92·5
85·08	3			,,	,,	98·3
73·87	3n	4375 (4)		,,	,,	22856·7
69·34	4	4369 (4)		,,	,,	80·4
67·15	1n			,,	6·4	91·9
		* 4356				
		4343 (1) (not seen)				
37·14	2n	4337 (3)		1·19	,,	23050·3
35·95	1			,,	,,	56·6
30·63	15	4331 (10)		,,	,,	84·9
21·95	4	4322 (3)		,,	,,	23131·3
10·69	2n	4311 (3)		1·18	,,	91·7
10·54	2n					
09·46	2			,,	,,	92·5
08·16	3			,,	6·5	98·3
05·99	< 1			,,	,,	23205·3
4296·97	< 1			,,	,,	65·7
96·52	5	4297 (3)		,,	,,	68·1
93·85	2			,,	,,	82·6
86·86	1			,,	,,	23320·6
86·04	4	4286 (3)		,,	,,	25·1
72·74	4	4272 (3)		1·17	,,	97·7
70·00	3	4269 (3)		,,	,,	23412·7
67·97	< 1			,,	,,	23·8
		4263 (not seen)				
51·68	4n	4251 (3)		,,	6·6	23513·5
45·54	10	4245 (10)		,,	,,	47·5
44·56	4			,,	,,	53·0
44·04	1			,,	,,	57·9
40·41	3			1·16	,,	76·0
38·37	10	4239 (8)		,,	,,	87·4
27·12	2	4227 (1)		,,	,,	23650·2
23·14	5n	4223 (5)		,,	,,	72·5
16·88	1			,,	,,	23707·6
15·77	5			,,	,,	13·8
14·85	1	4215 (10)		,,	,,	19·0
14·17	5			,,	,,	22·9
13·80	5	4214 (6)		,,	,,	24·9
09·75	4			,,	,,	47·8
09·53	4	4209 (8)		,,	,,	49·0
08·61	6			,,	,,	53·2
04·06	2	4204 (1)		1·15	,,	79·9
03·35	1			,,	,,	83·9
01·38	1	4201 (1)		,,	,,	95·1
4197·92	1	4198 (1)		,,	6·7	23814·6
96·85	< 1			,,	,,	20·7
95·02	2			,,	,,	31·1

* No doubt the Krypton II. line 4355·67, which is easily visible in Xenon when only small traces are present.

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum λ+	Reduction to Vacuum 1/λ −	Oscillation Frequency in Vacuo
4193·25	8	4193 (6)		1·15	6·7	23841·1
81·28	< 1			,,	,,	23909·4
80·20	10	4181 (10)		,,	,,	15·6
79·83	1			,,	,,	17·7
76·65	3	4176 (1)		,,	,,	35·9
71·08	1n	4172 (1)		,,	,,	67·9
62·25	3	4163 (3)		1·14	,,	24018·8
58·14	5	4159 (3)		,,	,,	42·5
56·27	< 1n			,,	,,	53·3
55·70	< 1			,,	,,	56·6
54·76	1			,,	,,	61·8
52·12	1			,,	,,	77·4
45·85	5	4146 (3)		,,	6·8	24113·7
42·12	2	4142 (1)		,,	,,	35·4
33·08	1			,,	,,	88·2
32·52	1	4132 (2)		,,	,,	91·5
31·11	1			,,	,,	99·8
22·01	1	4121 (1)		1·13	,,	24253·2
13·34	< 1			,,	,,	24304·3
12·25	2n	4112 (2)		,,	,,	10·8
10·53	1			,,	,,	21·0
10·18	1			,,	,,	23·0
09·20	6	4109 (6)		,,	,,	28·8
06·25	1	4106 (3)		,,	,,	46·3
05·10	2			,,	,,	53·1
03·19	1			,,	,,	65·5
00·48	2	4100 (2)		,,	,,	80·6
4099·01	4	4099 (3)		,,	6·9	89·2
95·04	3	4093 (1)		,,	,,	24412·9
87·38	< 1			1·12	,,	58·7
83·48	< 1n			,,	,,	82·0
83·07	< 1			,,	,,	84·5
82·79	2			,,	,,	86·1
78·85	2	4079 (1)		,,	,,	24509·8
78·33	1n			,,	,,	12·9
73·62	1			,,	,,	41·3
72·62	4n	4074 (1)		,,	,,	47·3
70·30	1			,,	,,	61·3
66·67	1			,,	,,	83·2
62·27	< 1			,,	,,	24609·9
61·30	1			,,	,,	16·8
61·06	2			,,	,,	17·2
60·60	3	4060 (1)		,,	,,	20·0
57·55	5n	4058 (6)		,,	,,	38·5
56·22	< 1n			,,	,,	46·6
53·75	2			1·11	,,	61·6
51·79	1			,,	,,	73·5
51·36	< 1n			,,	7·0	76·1
50·19	6	4050 (6)		,,	,,	83·2
47·45	1n			,,	,,	99·9
* 46·29	1			,,	,,	24707·0
44·96	2	4044 (1)		,,	,,	15·1
44·09	1			,,	,,	20·4

* *Cf.* Krypton II. 4046·30.

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda+$	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
4043·73	<1			1·11	7·0	24722·6
43·38	3	4043 (1)		”	”	24·8
39·39	<1			”	”	49·2
37·70	2	4037 (6)		”	”	59·6
37·43	3			”	”	61·2
33·02	<1			”	”	88·3
30·69	2			”	”	24802·6
28·72	3	4029 (1)		”	”	14·8
28·10	3			”	”	18·6
25·32	1	4025 (3)		”	”	35·7
21·76	1	4021 (1)		”	”	57·7
18·05	1			”	”	80·7
14·27	1			1·10	”	24904·2
03·71	<1			”	”	69·8
02·51	2	4002 (3)		”	7·1	77·2
01·32	1			”	”	84·1
00·66	1			”	”	88·8
3998·67	1n			”	”	25001·2
97·18	<1			”	”	10·5
94·55	1	3994 (2)		”	”	27·0
92·98	5	3991 (3)		”	”	36·9
90·40	3n			”	”	53·0
86·10	3	3986 (1)		”	”	80·1
81·69	2	3981 (1)		”	”	25107·9
79·35	2			”	”	22·6
76·47	1	3975 (1)		”	”	40·8
75·73	<1			1·09	”	45·5
74·14	<1			”	”	55·6
72·69	2n	3973 (2)		”	”	64·8
70·04	1			”	”	81·6
65·59	1			”	”	25209·8
		3957 (not seen)				
		3955 (not seen)				
51·73	<1			”	7·2	98·2
50·70	8	3951 (6)		”	”	25304·8
43·73	3	3944 (3)		”	”	49·5
* 42·29	1			”	”	58·7
39·05	2	3939 (1)		”	”	79·6
32·63	2			1·08	”	25421·1
29·73	1			”	”	39·8
		3926 (not seen; possibly Argon, 3925·90)				
23·56	2n	3923 (6)		”	”	79·9
22·67	10			”	”	85·6
18·71	3			”	”	25511·4
17·28	1n			”	”	20·7
15·46	3	3915 (1)		”	”	32·6
12·23	<1			”	”	53·7
11·77	1			”	”	56·7
08·00	7	3908 (4)		”	”	81·3

* *Cf.* Krypton II. 3942·28 (1).

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	$\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3906·02	3	3906 (1)		1·08	7·3	25594·2
05·71	1			,,	,,	96·2
03·82	2	3903 (1)		,,	,,	25608·6
03·30	1			,,	,,	12·0
3897·88	1			,,	,,	47·7
95·18	6	3894 (3)		1·07	,,	65·4
94·17	< 1			,,	,,	72·1
93·59	< 1			,,	,,	75·9
92·51	1			,,	,,	83·1
91·73	1			,,	,,	88·2
87·14	1			,,	,,	25718·6
86·88	2			,,	,,	20·3
85·54	1			,,	,,	29·1
85·15	4	3885 (3)		,,	,,	31·7
82·81	1			,,	,,	47·2
80·60	6	3880 (3)		,,	,,	61·9
79·35	1			,,	,,	70·2
77·95	8	3877 (3)		,,	,,	79·5
77·12	1			,,	,,	85·0
69·79	2	3870 (2)		,,	,,	25833·9
66·80	1n			,,	,,	53·9
62·71	< 1			,,	,,	81·3
61·19	4	3862 (2)		,,	,,	91·5
58·67	2	3858 (2)		,,	,,	25908·3
56·20	< 1			1·06	,,	24·9
54·44	4	3855 (1)		,,	,,	36·8
49·97	3n	3850 (2)		,,	,,	66·9
48·75	2	3849 (1)		,,	,,	75·2
47·57	2			,,	,,	83·1
46·43	1			,,	,,	90·8
42·05	5 }	3842 (4)		{ ,,	,,	26020·5
41·68	7 }			{ ,,	,,	27·0
39·13	1			,,	,,	40·3
37·87	1			,,	,,	48·8
29·90	1 }	3829 (1)		{ ,,	,,	26103·0
28·49	2 }			{ ,,	,,	12·7
28·15	1			,,	,,	15·3
* 26·99	2	3826 (1)		,,	,,	22·9
26·33	1			,,	,,	27·4
23·34	1	3824 (1)		,,	,,	47·8
16·93	1			1·05	7·4	91·7
15·32	1	3815 (1)		,,	,,	26202·8
11·93	1			,,	,,	26·0
11·19	4	3811 (3)		,,	,,	31·1
08·14	1			,,	,,	52·1
07·42	1	3807 (1)		,,	,,	57·1
01·86	2 }	3801 (1)		{ ,,	,,	95·5
01·13	1 }			{ ,,	,,	26300·6
3792·46	1			,,	,,	60·7
91·82	5	3792 (1)		,,	,,	65·2
87·46	1	3787 (1)		,,	,,	95·5
		† 3783				
81·13	10	3781 (6)		,,	,,	26439·7

* *Cf.* Xenon I.

† Probably 3783·28 Krypton II.

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3776·46	7	3776 (3)		1·04	7·4	26472·5
74·38	< 1			,,	,,	87·0
72·68	5	3773 (1)		,,	7·5	98·8
71·05	1	3770 (1)		,,	,,	26510·3
* 68·08	1			,,	,,	31·2
* 65·99	4	3766 (1)		,,	,,	45·9
63·52	2	3763 (2)		,,	,,	63·4
62·43	4	3762 (1)		,,	,,	71·2
58·13	1			,,	,,	26601·5
57·03	1	3757 (1)		,,	,,	09·3
56·14	1			,,	,,	13·6
* 51·80	1			,,	,,	46·4
50·86	4			,,	,,	53·0
45·85	5	3746 (3)		,,	,,	88·7
38·04	3	3737 (1)		,,	,,	26744·5
36·15	1			1·03	,,	58·0
31·33	1 }	3731 (2)		{ ,,	,,	92·6
30·29	3 }			{ ,,	,,	26800·1
28·33	1			,,	7·6	14·1
27·45	1			,,	,,	20·4
20·93	4	3721 (2)		,,	,,	67·4
		3717 (not seen) †				
‡ 15·73	1			,,	,,	26905·0
12·04	3 }	3712 (2)		{ ,,	,,	31·8
11·78	2 }			{ ,,	,,	33·6
09·88	1			,,	,,	47·4
09·07	2			,,	,,	52·3
08·29	3	3708 (1)		,,	,,	59·0
06·32	1			,,	,,	72·3
3698·87	1			,,	,,	27027·7
92·75	< 1			1·02	,,	72·5
89·96	1	3689 (1)		,,	,,	93·0
76·75	7	3677 (3)		,,	7·7	27190·2
72·68	2	3673 (2)		,,	,,	27220·4
69·28	5			,,	,,	45·7
66·90	5			,,	,,	63·3
65·26	1			,,	,,	75·5
64·60	1			,,	,,	80·4
64·05	3	3664 (1)		,,	,,	84·5
62·99	1			,,	,,	92·4
62·44	1			,,	,,	96·5
61·79	2	3662 (2)		,,	,,	27301·3
58·97	< 1			,,	,,	22·4
58·59	1 }	3658 (1)		{ ,,	,,	25·2
58·32	< 1 }			{ ,,	,,	27·2
57·88	1			1·01	,,	30·5
54·75	5	3655 (2)		,,	,,	53·9
53·27	2			,,	,,	65·0
49·71	4	3650 (1)		,,	,,	91·7
48·47	2			,,	,,	27401·0

* *Cf.* Krypton II. 3768·10 (1), 3765·98 (1), 3751·81 (1).
† Possibly Argon 3717
‡ *Cf.* Argon 3715.

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	$\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3646·83	<1			1·01	7·7	27411·4
45·05	2			„	„	26·8
44·58	2	3645 (6)		„	„	30·3
44·29	2			„	„	32·5
41·15	4	3641 (2)		„	„	56·1
36·17	2			„	7·8	93·7
35·49	1			„	„	98·8
34·34	1			„	„	27507·5
33·87	1n			„	„	11·1
32·30	4	3632 (2)		„	„	23·0
31·44	1			„	„	29·5
28·69	2			„	„	50·4
24·21	8	3624 (10)		„	„	84·4
23·28	5			„	„	91·5
21·75	1			„	„	27603·2
20·18	2			„	„	16·1
19·03	2			„	„	23·9
16·02	3	3616 (1)		1·00	„	46·9
14·59	1			„	„	57·8
12·52	3	3613 (4)		„	„	73·7
12·16	1			„	„	76·5
09·60	5	3610 (2)		„	„	96·1
07·58	1			„	„	27711·6
07·17	5	3607 (4)		„	„	14·9
06·22	3			„	„	22·1
02·03	2	3602 (1)		„	„	54·3
01·21	3			„	„	60·6
3596·75	5	3597 (3)		„	„	95·1
95·53	2			„	„	27804·4
93·61	1			„	7·9	19·3
92·14	1			„	„	30·7
91·34	1			„	„	36·9
89·40	<1			„	„	51·9
87·84	2			„	„	64·0
87·45	1			„	„	66·2
84·68	1			„	„	88·6
83·79	6	3584 (8)		„	„	95·5
79·85	6	3580 (8)		„	„	27926·2
78·71	1			„	„	35·1
78·14	1			„	„	39·6
76·80	5			0·99	„	50·0
75·08	1			„	„	63·5
74·56	1			„	„	67·6
74·26	1			„	„	69·9
70·31	1			„	„	28000·9
69·67	1			„	„	05·9
65·35	4	3565 (8)		„	„	39·8
* 64·40	4			„	„	47·3
63·15	1			„	„	57·1
62·37	3			„	„	63·3
61·53	3			„	„	68·9
58·12	1			„	„	96·8
56·64	2	3556 (3)		„	„	28108·5

* *Cf.* Krypton II. 3564·38 (4).

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3556·00	1			0·99	7·9	28113·6
54·60	1			,,	,,	24·7
53·42	1			,,	,,	34·0
52·29	6	3553 (5)		,,	,,	43·0
50·21	1			,,	8·0	59·5
49·39	1			,,	,,	65·9
48·35	1			,,	,,	74·1
47·04	1			,,	,,	84·5
45·04	2			,,	,,	28200·4
42·50	6	3543 (6)		,,	,,	20·6
40·09	3			,,	,,	39·9
37·56	3			0·98	,,	60·1
33·39	1			,,	,,	93·4
31·93	1			,,	,,	28305·1
31·43	1			,,	,,	09·1
30·76	1			,,	,,	14·5
30·40	1			,,	,,	17·4
28·14	1			,,	,,	35·5
27·39	1			,,	,,	41·6
26·04	<1			,,	,,	52·3
22·98	5	3523 (4)		,,	,,	77·0
19·26	3			,,	,,	28407·1
18·12	1			,,	,,	16·3
16·92	1			,,	,,	26·0
16·38	1			,,	,,	30·3
15·53	1			,,	,,	37·2
13·72	3			,,	,,	51·9
11·83	1			,,	,,	67·2
11·60	1			,,	,,	69·0
09·05	1	3510 (2)		,,	8·1	89·6
06·74	1			,,	,,	28508·4
03·99	1	3504 (1)		,,	,,	30·8
01·86	3	3501 (4)		,,	,,	48·1
00·53	2			,,	,,	59·0
3498·33	1			0·97	,,	77·0
98·04	4			,,	,,	79·3
95·00	1			,,	,,	28604·2
94·69	2			,,	,,	06·7
88·34	1			,,	,,	58·8
83·39	1			,,	,,	99·6
79·82	1			,,	,,	28729·0
79·29	1			,,	,,	33·4
75·43	1			,,	,,	65·3
74·42	1			,,	,,	73·7
72·59	3			,,	,,	88·9
71·47	1			,,	,,	98·1
70·73	1			,,	8·2	28804·2
70·27	1			,,	,,	08·0
69·31	1			,,	,,	16·0
68·35	5	3468 (2)		,,	,,	24·0
67·37	5			,,	,,	32·1
63·63	<1			,,	,,	63·2
62·69	<1			,,	,,	71·1
61·44	3	3461 (1)		,,	,,	81·5
58·90	6			0·96	,,	28902·7

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Living and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3455·87	1			0·96	8·2	2 928·1
54·41	7	3454 (1)		"	"	40·3
52·13	1			"	"	59·4
50·86	1			"	"	70·1
50·19	1			"	"	75·7
46·52	1			"	"	29006·6
45·01	1			"	"	19·2
44·61	1			"	"	22·7
44·38	4			"	"	24·6
43·49	1			"	"	32·1
42·08	1n			"	"	44·0
40·91	1n			"	"	53·9
38·88	1n			"	"	71·0
38·28	1			"	"	76·1
37·96	1			"	"	78·8
37·68	2			"	"	81·2
35·91	2			"	"	96·2
35·17	1			"	"	29102·4
32·18	1			"	8·3	27·7
31·71	4			"	"	31·7
30·62	1			"	"	41·0
29·13	1			"	"	53·6
* 28·95	1			"	"	55·2
28·61	1			"	"	58·0
28·20	1			"	"	61·5
26·61	1			"	"	75·1
24·88	1			"	"	89·8
20·89	4			"	"	29223·9
18·11	< 1			"	"	47·6
13·34	1n			0·95	"	88·5
09·60	< 1n			"	"	29320·1
07·76	1			"	"	36·5
07·25	1			"	"	40·9
05·62	1			"	"	54·9
04·06	3			"	"	68·4
00·02	1			"	"	29403·6
3397·65	1			"	"	23·8
† 96·72	2			"	"	31·9
95·68	1			"	8·4	40·9
94·92	2			"	"	47·4
92·73	4			"	"	66·4
90·78	3			"	"	83·3
90·13	1			"	"	89·0
† 87·26	1			"	"	29514·0
86·89	4			"	"	17·2
85·85	1			"	"	26·3
84·28	3			"	"	40·0
84·07	2			"	"	41·8
81·81	1			"	"	61·6
80·24	3			"	"	75·3
† 79·20	2			"	"	84·4
77·17	1			0·94	"	29602·2

* *Cf.* Krypton II. 3428·95 (1).
† *Cf.* Krypton II. 3396·72 (2), 3387·26 (1), 3379·18 (1)

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3374·11	1			0·94	8·4	29629·0
70·81	1			,,	,,	58·1
67·64	1			,,	,,	86·0
66·87	3n			,,	,,	92·8
64·82	1			,,	,,	29710·9
63·64	1			,,	,,	21·3
62·93	1			,,	,,	27·6
* 60·20	2			,,	8·5	51·6
58·13	4			,,	,,	70·1
56·09	2			,,	,,	88·1
54·51	1			,,	,,	29802·1
50·53	1n			,,	,,	37·7
49·91	3			,,	,,	43·1
45·11	1			,,	,,	85·9
44·41	1			,,	,,	92·1
40·85	1			,,	,,	29923·9
40·54	3			,,	,,	26·8
40·23	2			,,	,,	29·6
39·67	1			,,	,,	34·6
39·37	1			,,	,,	37·3
39·17	3			,,	,,	39·1
39·00	2			,,	,,	40·6
34·38	1			0·93	,,	82·1
32·97	5			,,	,,	94·8
31·80	5			,,	,,	30005·3
* 30·90	6			,,	,,	13·4
28·45	1			,,	,,	35·7
27·64	1			,,	,,	42·8
22·30	6			,,	8·6	91·0
20·21	2			,,	,,	30110·0
19·69	1			,,	,,	14·7
19·15	1			,,	,,	19·6
18·76	1			,,	,,	23·1
17·59	1			,,	,,	33·8
16·47	1			,,	,,	43·9
† 15·80	1			,,	,,	50·0
15·00	1			,,	,,	57·3
14·41	1			,,	,,	62·7
13·64	1n			,,	,,	69·7
13·01	1			,,	,,	75·4
12·34	<1			,,	,,	81·5
11·95	<1			,,	,,	85·1
10·52	5			,,	,,	98·2
06·94	3			,,	,,	30230·8
06·04	4			,,	,,	35·1
04·19	2			,,	,,	56·0
03·47	2			,,	,,	62·6
01·65	3			,,	,,	79·3
00·38	1n			,,	,,	90·9
3298·85	1			0·92	,,	30305·0
98·06	<1			,,	,,	12·3
96·07	4			,,	,,	30·6

* *Cf.* Krypton II. 3360·22 (2), 3330·88 (7).
† *Cf.* Krypton II. 3315·80 (1).

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3295·63	2			0·92	8·6	30334·6
94·70	<1n			„	„	43·2
94·09	1			„	„	48·8
93·17	<1			„	„	57·3
91·72	1n			„	„	70·7
90·44	<1			„	„	82·5
88·03	5			„	8·7	30404·6
86·17	1			„	„	21·9
85·93	8			„	„	24·1
84·81	1			„	„	34·5
83·75	<1n			„	„	44·3
81·36	1			„	„	66·5
80·94	<1			„	„	70·4
80·66	4			„	„	73·0
79·31	<1			„	„	85·5
78·61	3			„	„	92·0
77·41	3			„	„	30503·2
76·55	3			„	„	11·2
75·07	2			„	„	25·0
73·89	3			„	„	36·0
73·06	3			„	„	43·7
71·35	1			„	„	59·7
69·57	<1			„	„	76·4
69·11	5			„	„	80·7
68·31	2			„	„	88·2
67·52	1			„	„	95·5
67·19	4			„	„	98·6
66·21	1			„	„	30607·8
64·76	4			„	„	21·4
62·18	1			„	„	45·6
60·81	<1			„	„	58·5
60·42	<1			„	„	62·2
59·57	4			0·91	„	70·1
58·04	1			„	„	84·6
56·79	3			„	„	96·4
56·39	3			„	„	30700·1
53·38	5			„	„	28·6
50·70	3			„	8·8	53·9
49·14	<1			„	„	69·3
48·98	<1			„	„	70·2
48·76	1			„	„	72·2
47·80	5			„	„	81·3
46·99	4			„	„	89·0
45·17	<1			„	„	30806·2
44·30	3			„	„	14·5
42·98	7			„	„	27·0
41·26	1			„	„	43·4
39·41	6			„	„	61·0
37·50	1			„	„	79·2
36·97	5			„	„	84·3
35·85	4			„	„	95·0
35·49	<1			„	„	98·4
34·69	1			„	„	30906·1
34·36	1			„	„	09·2
33·56	<1			„	„	16·9

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3233·39	1			0·91	8·8	30918·5
31·83	5			,,	,,	33·5
30·80	<1			,,	,,	43·3
30·12	1			,,	,,	49·8
29·21	1			,,	,,	58·5
27·32	4			,,	,,	76·7
25·65	4			,,	,,	92·7
25·26	2			,,	,,	96·4
23·91	1			,,	,,	31009·4
23·52	2			,,	,,	13·2
23·14	4			,,	,,	16·8
* 22·40	1			,,	,,	24·0
21·45	1			,,	,,	33·1
21·18	2			,,	,,	35·8
19·97	<1			0·90	,,	47·4
18·13	<1			,,	,,	65·1
16·92	<1n			,,	,,	76·8
14·66	1			,,	8·9	98·6
14·30	4			,,	,,	31102·1
12·68	<1			,,	,,	17·8
12·46	1			,,	,,	19·9
10·40	3			,,	,,	39·9
09·54	4			,,	,,	48·2
06·49	1			,,	,,	77·8
06·21	<1			,,	,,	80·6
02·81	1			,,	,,	31213·7
02·17	2			,,	,,	19·9
01·94	<1			,,	,,	22·2
01·67	3			,,	,,	24·8
3199·87	1			,,	,,	42·3
99·39	1			,,	,,	47·1
98·75	4			,,	,,	53·3
96·68	3			,,	,,	73·6
96·37	5			,,	,,	76·6
95·10	<1			,,	,,	89·0
93·86	<1			,,	,,	31301·2
93·35	2			,,	,,	06·2
88·80	<1			,,	,,	50·9
87·91	<1			,,	,,	59·6
87·60	2			,,	,,	62·7
86·93	1			,,	,,	69·3
85·93	<1			,,	,,	79·1
85·35	5			,,	,,	84·8
84·74	3			,,	,,	90·8
84·42	2			0·89	,,	94·0
81·57	1			,,	,,	31422·0
80·62	<1			,,	9·0	31·4
79·40	5			,,	,,	43·5
77·27	2			,,	,,	64·6
76·18	3			,,	,,	75·4
† 75·80	3			,,	,,	79·1
75·38	5			,,	,,	83·3
73·15	1n			,,	,,	31505·4

* *Cf.* Krypton II. 3222·40 (1).

† *Cf.* Krypton II. 3175·78 (2).

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda+$	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
3170·81	1			0·89	9·0	31528·7
68·77	<1			,,	,,	49·0
67·67	<1			,,	,,	59·9
66·92	<1			,,	,,	67·4
66·26	1			,,	,,	74·0
64·63	2			,,	,,	90·3
64·43	1			,,	,,	92·3
63·10	2			,,	,,	31605·6
60·82	2			,,	,,	28·4
59·97	1			,,	,,	36·9
56·85	2			,,	,,	68·5
55·66	3			,,	,,	80·1
53·58	3			,,	,,	31701·0
53·14	4			,,	,,	05·4
51·98	5			,,	,,	17·1
51·11	6			,,	,,	25·8
50·86	6			,,	,,	28·4
49·11	1			,,	,,	46·0
48·17	1n			,,	,,	55·5
46·84	<1			,,	9·1	68·8
45·17	1			,,	,,	85·7
43·77	2			,,	,,	99·8
42·69	1			,,	,,	31810·8
41·77	2			0·88	,,	20·1
39·21	1			,,	,,	46·0
38·87	1			,,	,,	49·5
38·46	6			,,	,,	53·7
34·86	1			,,	,,	90·3
32·87	1			,,	,,	31910·5
30·48	2n			,,	,,	34·9
26·90	1			,,	,,	71·5
* 25·86	2			,,	,,	82·1
25·12	<1			,,	,,	89·7
24·75	1			,,	,,	93·5
24·15	1			,,	,,	99·6
22·32	1			,,	,,	32018·4
22·00	8			,,	,,	21·7
21·15	1			,,	,,	30·4
19·34	1			,,	,,	49·0
16·88	1			,,	,,	74·3
14·56	4			,,	9·2	98·2
13·69	<1			,,	,,	32107·0
12·87	3			,,	,,	15·5
08·72	1n			,,	,,	58·4
07·91	2n			,,	,,	76·8
06·50	5			,,	,,	81·4
05·75	1			,,	,,	89·1
04·60	3			,,	,,	32201·1
03·64	2			,,	,,	11·0
03·38	<1			,,	,,	13·7
02·88	1			,,	,,	18·9
02·54	<1			,,	,,	22·4
01·68	2n			0·87	,,	31·4

* *Cf.* Xenon I.

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda+$	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
3100·04	3			0·87	9·2	32248·4
3098·68	1			,,	,,	62·6
98·33	1			,,	,,	66·2
97·03	1			,,	,,	79·8
94·91	1			,,	,,	32301·9
94·69	2			,,	,,	04·2
93·55	1n			,,	,,	16·1
92·57	2			,,	,,	26·4
91·22	5			,,	,,	40·7
90·15	3			,,	,,	51·7
89·07	1			,,	,,	63·0
85·74	<1			,,	,,	97·9
83·70	6			,,	9·3	32419·3
83·05	1			,,	,,	26·1
82·74	2			,,	,,	29·4
80·61	3			,,	,,	51·8
79·86	4			,,	,,	59·8
77·82	1			,,	,,	81·2
75·47	1			,,	,,	32506·1
73·62	4			,,	,,	25·6
73·31	1			,,	,,	28·9
71·49	3			,,	,,	48·2
70·19	2			,,	,,	62·0
68·71	1			,,	,,	77·7
67·43	4			,,	,,	91·3
66·69	1			,,	,,	99·1
65·33	6			,,	,,	32613·6
63·49	2			,,	,,	33·2
61·71	3			0·86	,,	52·2
57·16	<1			,,	,,	32700·8
56·63	3			,,	,,	06·5
55·42	2			,,	,,	19·4
54·62	4			,,	,,	28·0
51·41	1			,,	9·4	62·4
51·14	1			,,	,,	65·2
49·04	1			,,	,,	87·8
48·31	1			,,	,,	95·7
47·93	1n			,,	,,	99·6
46·40	3			,,	,,	32816·2
45·42	3			,,	,,	32·3
* 44·91	2			,,	,,	41·69
44·36	2			,,	,,	38·2
42·22	3			,,	,,	61·3
37·47	1			,,	,,	32912·5
37·00	2n			,,	,,	17·8
34·36	3			,,	,,	46·5
33·86	1			,,	,,	51·9
33·22	2			,,	,,	58·9
32·63	<1			,,	,,	65·3
31·97	1n			,,	,,	72·5
29·91	2			,,	,,	94·9
29·05	1n			,,	,,	33004·2
28·49	<1			,,	,,	10·4

* *Cf.* Krypton II. 3044·92 (1).

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda+$	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
3027·77	1			0·86	9·4	33018·2
27·41	1			,,	,,	22·1
26·66	3			,,	,,	30·3
23·99	5			,,	9·5	59·4
23·83	5			,,	,,	61·1
20·47	1			0·85	,,	97·9
19·96	<1			,,	,,	33103·5
17·89	<1			,,	,,	26·2
17·58	4			,,	,,	29·6
15·91	1			,,	,,	48·0
15·57	2			,,	,,	51·7
14·77	3			,,	,,	60·5
14·32	2			,,	,,	65·5
13·53	1			,,	,,	74·2
13·05	<1			,,	,,	79·5
12·45	<1			,,	,,	86·1
11·44	<1			,,	,,	97·2
10·85	3			,,	,,	33203·7
09·16	3			,,	,,	22·4
04·81	1			,,	,,	70·8
04·48	4			,,	,,	74·1
04·11	3			,,	,,	78·2
02·01	3			,,	,,	33301·5
01·70	3			,,	,,	05·0
00·12	<1			,,	,,	22·5
2999·44	2			,,	,,	30·1
99·24	2n			,,	,,	32·3
97·69	2			,,	,,	49·5
95·11	1			,,	9·6	78·2
94·86	2			,,	,,	83·2
93·07	5			,,	,,	33400·9
91·91	<1			,,	,,	13·9
91·65	2			,,	,,	16·8
91·42	3			,,	,,	19·3
90·74	1			,,	,,	26·9
90·48	1			,,	,,	29·9
87·00	2			,,	,,	57·6
86·32	3			,,	,,	76·4
85·72	4			,,	,,	83·2
84·77	4			,,	,,	93·8
82·39	3			0·84	,,	33520·6
81·47	2			,,	,,	30·9
80·26	<1			,,	,,	44·5
79·48	6			,,	,,	53·3
76·95	<1			,,	,,	81·8
76·58	3			,,	,,	86·0
74·97	2			,,	,,	33604·2
73·65	3			,,	,,	19·1
72·48	1			,,	,,	32·3
71·40	2			,,	,,	44·6
71·08	1			,,	,,	48·2
70·65	3			,,	9·7	53·0
70·29	1			,,	,,	57·0
69·95	2			,,	,,	60·9
69·63	1			,,	,,	64·5

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda+$	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
2969·42	1			0·84	9·7	33666·9
68·74	3			,,	,,	74·6
67·11	3			,,	,,	93·1
65·13	3			,,	,,	33715·6
64·35	3			,,	,,	24·5
63·59	3			,,	,,	33·1
61·69	1			,,	,,	53·4
* 60·93	2			,,	,,	63·5
60·53	3			,,	,,	68·0
59·55	4			,,	,,	79·2
57·77	5			,,	,,	99·5
56·05	1			,,	,,	33819·2
55·08	<1			,,	,,	30·3
54·84	1			,,	,,	33·1
54·27	3			,,	,,	39·6
54·08	1			,,	,,	41·8
51·73	1			,,	,,	68·7
50·91	<1			,,	,,	78·1
49·88	2n			,,	,,	90·0
48·23	4			,,	,,	33908·9
47·69	5			,,	,,	15·2
46·52	1			,,	,,	28·6
45·71	2			,,	,,	38·0
45·41	5			,,	9·8	41·4
44·78	1			,,	,,	48·6
43·59	2			,,	,,	62·3
43·07	1			,,	,,	68·3
42·25	4			0·83	,,	77·8
41·55	3			,,	,,	86·0
40·37	5			,,	,,	99·5
39·89	3			,,	,,	34005·1
39·29	4			,,	,,	12·0
38·38	<1			,,	,,	22·5
37·61	<1			,,	,,	31·5
36·03	6			,,	,,	49·8
34·98	1			,,	,,	62·0
32·92	4			,,	,,	85·9
32·27	3			,,	,,	93·5
30·44	5			,,	,,	34114·8
29·41	1			,,	,,	26·8
28·20	<1			,,	,,	40·9
27·74	<1			,,	,,	46·2
27·30	1			,,	,,	51·4
26·27	4			,,	,,	63·4
25·58	<1			,,	,,	71·5
25·11	<1			,,	,,	77·0
24·56	1			,,	,,	83·4
24·12	3			,,	,,	88·5
23·68	4			,,	,,	93·7
22·62	<1			,,	,,	34206·1
22·10	<1			,,	,,	12·2
21·74	<1			,,	,,	16·4
20·05	3			,,	9·9	36·1

* *Cf.* Krypton II. 2960·93 (2).

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
2918·74	<1			0·83	9·9	34251·5
17·76	4			,,	,,	63·0
16·81	3			,,	,,	74·1
15·87	<1			,,	,,	95·2
15·22	1			,,	,,	92·8
14·28	4			,,	,,	34303·9
12·56	5n			,,	,,	24·1
12·06	5			,,	,,	30·0
11·63	1			,,	,,	35·1
11·38	<1			,,	,,	38·1
10·54	1			,,	,,	48·0
07·35	4			,,	,,	85·7
06·71	5			,,	,,	93·3
05·26	<1n			,,	,,	34410·4
04·79	<1			,,	,,	16·0
04·32	1			,,	,,	21·6
02·84	1			0·82	,,	39·1
02·47	1			,,	,,	43·5
00·59	1			,,	,,	65·8
2899·56	<1			,,	,,	78·1
98·97	<1			,,	,,	85·1
98·65	1			,,	,,	88·9
98·19	1			,,	,,	94·4
97·85	1			,,	,,	98·4
96·79	4			,,	10·0	34511·0
96·20	<1			,,	,,	18·0
95·40	4			,,	,,	27·5
91·86	4			,,	,,	69·8
90·81	<1			,,	,,	82·4
90·14	2			,,	,,	90·4
89·22	2			,,	,,	34601·4
88·74	<1			,,	,,	07·2
87·29	2			,,	,,	24·5
86·86	3			,,	,,	29·7
84·39	<1			,,	,,	59·4
83·89	2			,,	,,	65·4
79·94	1			,,	,,	34712·9
77·87	1			,,	,,	37·8
73·65	2			,,	,,	88·9
72·91	1			,,	,,	97·9
71·85	4			,,	10·1	34810·7
71·43	3			,,	,,	15·8
71·27	5			,,	,,	17·7
69·71	<1			,,	,,	36·6
68·61	1			,,	,,	48·8
67·55	1			,,	,,	62·9
66·96	1			,,	,,	70·0
64·92	4n			0·81	,,	94·9
64·32	1			,,	,,	34902·2
64·00	<1			,,	,,	06·1
62·56	3			,,	,,	23·7
62·06	1			,,	,,	29·8
58·03	1			,,	,,	79·0
57·29	<1n			,,	,,	88·1
56·80	1			,,	,,	94·1

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
2855·92	1			0·81	10·1	35004·9
55·42	<1			,,	,,	11·0
54·70	4n			,,	,,	19·9
53·78	1			,,	,,	31·2
53·28	<1			,,	,,	37·3
52·55	2n			,,	,,	58·5
51·10	1			,,	,,	64·1
50·41	1			,,	,,	72·6
47·81	4			,,	10·2	35104·5
46·63	2n			,,	,,	19·1
46·07	2			,,	,,	26·0
45·26	2			,,	,,	36·0
* 44·60	3			,,	,,	44·1
44·28	1			,,	,,	48·1
41·46	<1			,,	,,	83·0
* 41·10	1			,,	,,	87·4
40·22	<1			,,	,,	98·3
39·75	2			,,	,,	35204·2
38·99	2			,,	,,	13·6
38·55	1			,,	,,	19·0
37·03	<1			,,	,,	37·9
36·32	<1			,,	,,	46·7
35·16	<1			,,	,,	61·2
33·32	2			,,	,,	84·1
33·08	1			,,	,,	87·1
32·59	<1			,,	,,	93·2
32·19	<1			,,	,,	98·2
29·35	1			,,	,,	35323·6
28·84	1			,,	,,	40·0
28·37	1			,,	,,	45·8
28·01	1			,,	,,	50·4
27·62	4			,,	,,	55·2
27·06	2n			,,	,,	62·2
26·18	4			,,	,,	73·2
24·25	1			0·80	,,	97·4
22·67	2			,,	10·3	35417·1
22·36	1			,,	,,	21·0
20·22	1			,,	,,	47·9
19·87	2			,,	,,	52·3
17·51	3			,,	,,	82·0
16·10	5			,,	,,	99·8
14·62	6			,,	,,	35518·5
* 11·81	3			,,	,,	54·0
10·67	2			,,	,,	68·4
10·00	<1			,,	,,	76·9
09·68	1			,,	,,	80·9
09·23	3			,,	,,	86·6
08·77	1			,,	,,	92·5
07·39	4			,,	,,	35610·0
06·83	<1			,,	,,	17·1
05·24	1			,,	,,	37·3
04·82	1			,,	,,	42·6
03·15	2			,,	,,	63·8

* *Cf.* Krypton II. 2844·59 (3), 2841·10 (1), 2811·81 (2).

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda+$	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
2800·37	5			0·80	10·3	35699·3
2798·01	2			,,	10·4	35729·4
97·74	1			,,	,,	32·7
97·29	3			,,	,,	38·5
96·73	2			,,	,,	45·6
95·00	5			,,	,,	67·8
89·64	1			,,	,,	35836·5
85·95	1			,,	,,	84·0
85·53	1			,,	,,	89·4
85·10	1			,,	,,	95·0
83·49	4			0·79	,,	35915·7
82·86	2			,,	,,	23·8
82·45	1			,,	,,	29·1
80·86	1			,,	,,	49·7
80·02	1			,,	,,	60·5
79·78	2			,,	,,	63·7
78·11	3			,,	,,	85·3
77·10	4			,,	,,	98·4
74·99	3			,,	10·5	36025·6
74·02	1			,,	,,	38·3
73·68	2			,,	,,	42·7
72·54	4			,,	,,	57·5
70·56	1			,,	,,	83·3
69·35	2			,,	,,	99·0
67·96	1			,,	,,	36117·2
67·71	1			,,	,,	20·4
66·33	2			,,	,,	38·5
66·10	1			,,	,,	41·5
63·71	<1			,,	,,	72·7
63·18	1			,,	,,	79·7
62·90	2			,,	,,	83·3
61·73	4			,,	,,	98·7
60·88	3			,,	,,	36209·8
59·87	<1			,,	,,	23·1
59·36	3			,,	,,	29·8
58·55	1			,,	,,	40·4
58·02	3n			,,	,,	47·4
57·76	1n			,,	,,	50·8
* 56·64	1			,,	,,	52·4
55·08	3			,,	,,	86·1
54·80	2			,,	,,	89·8
54·05	<1			,,	,,	99·7
51·09	1			,,	10·6	36338·6
48·96	<1n			,,	,,	66·8
48·02	3			,,	,,	79·3
44·26	1			,,	,,	36429·1
43·71	<1			,,	,,	36·4
43·24	1n			,,	,,	42·6
40·93	3			0·78	,,	73·3
39·91	1			,,	,,	87·0
39·40	1			,,	,,	93·7
37·18	2			,,	,,	36523·4
34·31	5n			,,	,,	61·7

* *Cf.* Krypton II. 2756·66 (1).

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum		Oscillation Frequency in Vacuo
				$\lambda +$	$\frac{1}{\lambda} -$	
2734·11	1			0·78	10·6	36564·4
* 33·36	4n			"	"	74·4
32·48	1			"	"	86·2
31·61	1			"	"	97·8
28·37	2			"	"	36641·3
27·38	3			"	"	54·6
25·45	2			"	10·7	80·6
24·71	<1			"	"	90·5
* 23·56	<1			"	"	36706·1
23·09	1			"	"	12·3
20·41	1			"	"	48·5
18·92	<1			"	"	68·6
17·47	7			"	"	88·2
15·91	1			"	"	36809·4
15·07	4			"	"	20·7
14·20	<1			"	"	32·6
13·50	1			"	"	42·1
12·06	1			"	"	61·6
11·69	2n			"	"	66·7
11·16	1			"	"	73·9
08·65	3			"	"	36908·1
07·49	2n			"	"	23·9
07·15	1			"	"	28·7
06·89	2			"	"	32·1
04·61	1			"	"	63·2
03·58	4			"	"	77·3
02·48	3			"	10·8	92·2
01·99	1			"	"	99·0
01·71	1			"	"	37002·8
2699·29	1n			"	"	36·0
27·70	1			0·77	"	57·8
* 96·72	4			"	"	71·3
96·08	1			"	"	80·0
95·52	1			"	"	87·8
95·28	1			"	"	91·1
94·27	2			"	"	37105·0
* 91·92	1			"	"	37·4
91·63	1			"	"	41·4
91·44	1			"	"	44·0
* 90·33	1			"	"	59·4
89·82	1n			"	"	66·4
87·12	3			"	"	37203·8
85·73	1			"	"	23·0
85·49	<1			"	"	26·4
82·84	1n			"	"	63·1
80·12	1			"	"	37301·0
79·57	<1			"	"	08·6
78·70	2			"	10·9	20·6
* 77·29	8			"	"	40·3
76·22	<1			"	"	55·2
75·51	<1			"	"	65·1
73·95	2n			"	"	87·0
72·35	3			"	"	37409·3

* *Cf.* Krypton II. 2733·38 (4), 2323·46 (1), 2696·71 (4), 2691·94 (1), 2690·35 (1), 2677·30 (2).

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda+$	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
*2670·80	2			0·77	10·9	37431·1
70·40	1			"	"	36·7
69·12	4			"	"	54·6
68·14	3			"	"	68·4
65·30	1			"	"	37508·3
64·97	1			"	"	13·0
64·61	<1n			"	"	18·0
63·43	2			"	"	34·7
62·60	<1n			"	"	46·4
61·99	<1			"	"	55·0
61·14	2			"	"	67·0
59·51	1			"	"	90·0
58·37	2			"	"	37616·1
55·57	1			"	"	45·8
53·47	<1			0·76	11·0	75·5
52·93	1			"	"	83·2
52·28	2n			"	"	92·4
51·69	1			"	"	37700·8
50·34	1			"	"	20·0
49·76	1			"	"	28·3
* 48·79	1			"	"	42·1
43·89	1n			"	"	37812·1
43·56	1			"	"	16·8
42·68	1			"	"	29·4
41·25	3			"	"	49·9
39·30	2			"	"	77·8
37·63	3			"	"	87·5
36·95	2			"	"	37911·6
36·58	2			"	"	16·9
35·78	1			"	"	28·4
35·20	<1			"	"	36·8
34·33	3			"	"	49·3
34·05	1			"	"	53·3
33·53	1			"	"	60·8
30·56	2			"	11·1	38003·6
29·70	3n			"	"	16·0
27·10	1			"	"	24·7
26·12	1			"	"	38·9
* 24·65	1			"	"	89·2
23·31	1n			"	"	38108·7
21·88	1			"	"	29·5
21·52	1			"	"	34·7
20·07	<1			"	"	55·8
19·83	1			"	"	59·3
17·06	1			"	"	99·7
† 16·79	1			"	"	38203·7
15·83	1			"	"	17·7
15·54	1			"	"	21·9
14·13	3			"	"	42·5
12·61	1n			"	"	64·8
11·17	1			"	"	85·9
10·73	1			"	"	92·4

* *Cf.* Krypton II. 2670·78 (1), 2648·80 (1), 2624·63 (1).
† *Cf.* Krypton II. 2616·80 (2).

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
2609·04	3			0·75	11·2	38317·2
07·68	1			,,	,,	37·1
07·09	2			,,	,,	45·8
05·69	10			,,	,,	66·4
00·29	3			,,	,,	38446·1
2599·77	<1			,,	,,	53·7
98·59	3n			,,	,,	71·2
97·14	4n			,,	,,	92·7
95·19	1			,,	,,	38521·6
94·81	1			,,	,,	27·3
93·70	<1			,,	,,	43·5
91·84	2			,,	,,	71·4
91·26	1			,,	,,	80·1
90·59	3			,,	,,	90·1
88·52	1			,,	11·3	38620·8
87·72	1			,,	,,	32·8
85·45	1			,,	,,	66·7
84·04	1			,,	,,	87·8
83·90	1			,,	,,	89·9
82·74	1			,,	,,	97·3
* 81·84	1n			,,	,,	38720·8
78·80	2			,,	,,	66·4
78·51	3			,,	,,	70·8
77·11	3			,,	,,	91·9
74·18	1n			,,	,,	38836·0
73·06	1			,,	,,	52·9
* 72·46	2			,,	,,	62·0
70·41	1			,,	,,	93·0
69·53	1			,,	,,	38906·3
68·94	2			,,	,,	15·3
67·62	<1			,,	11·4	35·2
67·25	1			,,	,,	40·8
65·09	<1			,,	,,	73·6
64·12	1			0·74	,,	88·3
61·04	2			,,	,,	39035·2
60·11	1			,,	,,	49·4
57·91	1			,,	,,	83·0
56·30	1			,,	,,	39107·6
51·85	2			,,	,,	75·8
50·70	1			,,	,,	93·5
49·92	3			,,	,,	39205·5
49·05	1			,,	11·5	18·8
46·89	<1			,,	,,	52·1
46·57	1n			,,	,,	57·0
44·27	1			,,	,,	92·5
42·03	1			,,	,,	39327·1
41·22	<1			,,	,,	39·7
39·08	1			,,	,,	72·8
38·16	1			,,	,,	87·1
37·04	2			,,	,,	39404·5
36·08	2			,,	,,	19·4
33·47	2			,,	,,	60·1
31·45	1n			,,	,,	91·5

* *Cf.* Krypton II. 2581·84 (1), 2572·44 (1).

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda+$	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
2530·33	1			0·74	11·6	39509·0
27·10	4			,,	,,	59·4
26·97	4			,,	,,	61·5
24·58	2			,,	,,	98·9
24·13	2			,,	,,	39606·0
21·58	1			,,	,,	46·1
20·28	1			,,	,,	66·5
19·17	3n			,,	,,	84·0
17·21	1n			0·73	,,	39714·9
15·26	1			,,	,,	45·7
14·85	<1			,,	,,	52·2
14·70	<1			,,	,,	54·6
14·16	1n			,,	,,	63·1
* 13·52	1n			,,	,,	73·2
11·43	1n			,,	11·7	39806·2
10·65	2			,,	,,	18·6
09·89	<1			,,	,,	30·7
05·05	1			,,	,,	39907·7
01·16	2			,,	,,	69·8
2498·20	1			,,	,,	40017·1
95·27	1			,,	,,	64·1
* 94·11	3			,,	11·8	82·8
93·60	< 1			,,	,,	90·9
93·18	1			,,	,,	97·6
92·69	< 1			,,	,,	40105·5
91·93	2n			,,	,,	17·7
90·89	4n			,,	,,	34·5
90·23	4n			,,	,,	45·1
86·86	1			,,	,,	99·6
86·46	4			,,	,,	40206·0
85·13	1			,,	,,	27·5
83·59	1			,,	,,	52·5
79·98	1			,,	,,	40301·1
79·25	1			,,	,,	13·0
76·02	10			,,	11·9	75·5
72·50	1			,,	,,	40433·0
71·42	2			,,	,,	50·6
70·30	2			,,	,,	69·0
69·57	2			0·72	,,	81·0
† 68·54	2n			,,	,,	97·9
63·72	1			,,	,,	40577·1
63·14	1			,,	,,	86·7
55·19	1			,,	12·0	40718·0
54·40	1n			,,	,,	31·2
52·76	2			,,	,,	58·4
51·50	1			,,	,,	79·3
51·02	1			,,	,,	87·3
49·16	1			,,	,,	40818·3
48·63	1			,,	,,	27·2
47·79	1			,,	,,	41·2
47·21	1			,,	,,	60·9
46·23	1			,,	,,	67·2

* *Cf.* Krypton II. 2513·50 (1), 2494·10 (2).
† *Cf.* Krypton II. 2468·56 (2).

SECOND XENON SPECTRUM—*continued.*

Wave-length	Intensity and Character	Liveing and Dewar	Runge	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
2436·63	1			0·72	12·1	41028·2
35·59	1n			,,	,,	45·7
33·75	1			,,	,,	76·8
32·87	1			,,	,,	91·6
29·11	1			,,	,,	41155·2
† 25·18	2n			,,	12·2	41222·8
23·08	1			,,	,,	57·6
22·28	3			,,	,,	71·2
21·36	1			0·71	,,	86·9
18·83	1			,,	,,	41330·1
18·47	1			,,	,,	36·2
16·86	1			,,	,,	63·8
14·88	1			,,	,,	97·7

† *Cf.* Krypton II. 2425·16 (1).

The Study of Hydro-Aromatic Substances.—Report of the Committee, consisting of Dr. E. DIVERS (*Chairman*), Professor A. W. CROSSLEY (*Secretary*), Professor W. H. PERKIN, Dr. M. O. FORSTER, *and* Dr. H. R. LE SUEUR.

Recent Work on Hydro-Aromatic Substances. *By* Professor A. W. CROSSLEY.

THE following is a summary of the work published on hydro-aromatic compounds since the preparation of the last report.[1]

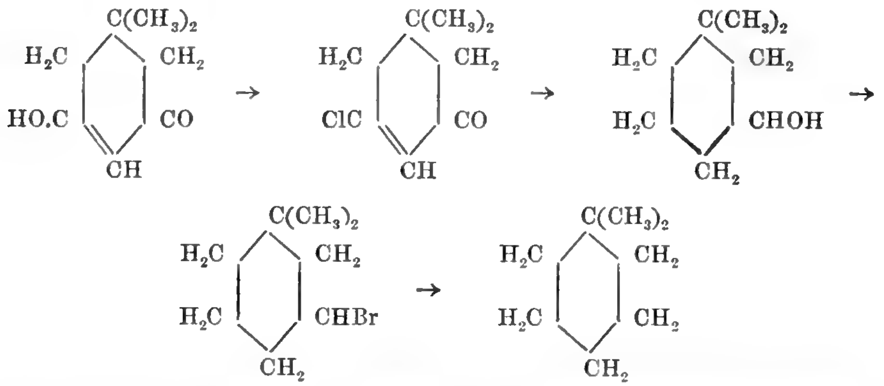
Petroleum.—The colourless and yellow distillates from naphtha give rotations[2] varying from +0·2 to +2·3 divisions of the Soleil-Ventzke scale in a tube 200 mm. long, the highest value being given by yellow cylinder oil from Baku naphtha. 'Benzine' and petroleum from Grosny naphtha, also the yellow American cylinder oil 'Viscolite,' exhibit dextro rotations.

Hydrocarbons.—The hydrocarbon C_8H_{16}, obtained by Wreden by the action of hydriodic acid on camphoric acid, has been regarded, from a consideration of its physical properties only, as 1 : 3-dimethylhexahydrobenzene. Balbiano and Angeloni[3] have now afforded chemical proof of this fact by a study of the oxidation products of the hydrocarbon.

Another hydrocarbon of the formula C_8H_{16} was prepared indirectly from camphoric acid, *i.e.*, by the reduction of laurolene (C_8H_{14}) and isolaurolene (C_8H_{14}) by Zelinsky[4] and Lepeschkin in 1901, who considered, principally from a study of its physical properties, that it was the then unknown 1 : 1-dimethylhexahydrobenzene. This latter substance has recently been obtained from dimethyldihydroresorcin as a starting-point,[5]

[1] *Reports*, 1904, p. 60. [2] Rakusin, *J. Russ. Chem. Soc.*, 1904, **36**, 554.
[3] *Gaz. Chim. Ital.*, 1905, **35** (1), 144. [4] *Annalen*, **319**, 311.
[5] Crossley and Renouf, *Proc. C. S.* 1905, **20**, 242.

the various steps involved being adequately indicated by the following formulæ :—



It has not so far been found possible to prove whether the synthetical 1 : 1-dimethylhexahydrobenzene is identical with Zelinsky's hydrocarbon, though preliminary experiments would point to their non-identity. Certainly neither laurolene nor isolaurolene is identical with 1 : 1-dimethyl-Δ^3-tetrahydrobenzene, which has also been recently prepared.[1]

Chloromethylhexahydrobenzene.[2]

Brunel[3] has shown that tetrahydrobenzene may be prepared directly from hydroxyhexahydrobenzene by the action of dehydrating agents, *e.g.*, phosphoric oxide, zinc chloride, or potassium hydrogen sulphate. In the latter case the yield amounts to 82 to 83 per cent. of the theoretical, the loss being due to the formation of condensation products. When tetrahydrobenzene[4] is acted on with mercuric oxide, iodine, and acetic anhydride, or with mercuric acetate and iodine, iodocyclohexyl acetate is obtained as a yellow oil with aromatic odour. Iodocyclohexyl propionate is also described.

On carefully heating the xanthogenic ether of 1-hydroxy-2-methylhexahydrobenzene[5] a hydrocarbon is obtained which, as it gives β-methyladipic acid on oxidation, must be 1-methyl-Δ^3-tetrahydrobenzene.

Methyltetrahydrobenzene.[6] (Compare p. 155.)

The preparation and properties of $\Delta^{1:3}$-dihydrobenzene, briefly alluded to in the last report,[7] have been described in detail.[8]

Hydrogenation.—Sabatier and Senderens[9] have published a general survey of their work on the reduction of various classes of organic substances by means of hydrogen in presence of finely divided metals. The first portion of the paper contains a description of the apparatus employed, choice of temperature, length of activity of the catalyst, &c. Then follows a description of the various substances which have been prepared. The great importance of choice of temperature in this reaction is well illustrated by the case of phenol. At 140° to 160° pure hydroxyhexahydrobenzene is obtained ; at 215° to 230° a mixture of hydroxy-

[1] Crossley and Renouf, *Proc. C. S.*, 1905, **21**, 209.
[2] Sabatier and Mailhe, *Compt. Rend.*, 1905, **140**, 840.
[3] *Bull. Soc.*, 1905 (3), **33**, 270.
[4] Brunel, *Compt. Rend.*, 1904, **139**, 1029.
[5] Markownikoff and Stadnikoff, *Annalen*, 1904, **336**, 310.
[6] Sabatier and Mailhe, *Compt. Rend.*, 1905, **140**, 350.
[7] *Reports*, 1904, p. 65.
[8] Crossley, *J. C. S.*, 1904, **85**, 1403.
[9] *Ann. Chim. Phys.*, 1905 (8). **4**, 319.

and ketohexahydrobenzene[1]; but at 250° to 300° the benzene ring is not hydrogenated, phenol being simply reduced to benzene; whilst at still higher temperatures the benzene formed is partially decomposed into methane.

Holleman, Van der Laan, and Slejper,[2] have shown that when phenol is passed with hydrogen over reduced nickel at a temperature of 140° to 150° a mixture of hydroxy- and ketohexahydrobenzene is formed. These two substances may be separated by taking advantage of the formation of a condensation product between the ketone and benzaldehyde. Similar experiments have been previously described by Sabatier and Senderens.[3]

Hydroxy-derivatives. — On heating heptanaphthylene oxide[4] with water it is converted into 3 : 4-dihydroxy-1-methylhexahydrobenzene.[5]

Ketohexahydrobenzene is readily converted by means of Grignard's reaction into tertiary alcohols of the following type[6]:—

$$CH_2\begin{matrix} \diagup CH_2—CH_2 \diagdown \\ \diagdown CH_2—CH_2 \diagup \end{matrix}CR.OH$$

substances which are insoluble in water, and which on treatment with dehydrating agents are converted into the corresponding tetrahydrobenzenes. Alcohols in which R may be replaced by the groups methyl, ethyl, propyl, isobutyl, isoamyl, phenyl, tolyl, benzyl and cyclohexyl, together with certain derivatives, and the corresponding tetrahydrobenzenes, are described.

The hydrogenation of *o*-cresol[7] takes place regularly in presence of reduced nickel at 200° to 220°, giving rise to 1-hydroxy-2-methylhexahydrobenzene. When this substance is heated with zinc chloride two isomeric methyltetrahydrobenzenes are formed, boiling respectively at 109° and 103° to 105°. The hydroxy derivative can be converted by oxidation with chromic acid, or better by passing its vapour over copper heated to 300°, into 1-keto-3-methylhexahydrobenzene. *m*-Cresol on hydrogenation gives a mixture of 1-hydroxy- and 1-keto-3-methylhexahydrobenzene, which can be worked up for either alcohol or ketone, in the first case by passing the product with excess of hydrogen over reduced nickel at a temperature of 140° to 150°; and, in the second, by passing the mixture with hydrogen over copper at a temperature of 330°. Similar experiments have been carried out with *p*-cresol.

The methyl and ethyl ethers of hydroxyhexahydrobenzene[8] may be prepared either by the action of alkyl iodide on the sodium derivative of the alcohol, or by the reduction of the corresponding alkyl phenyl ethers.

Amines.—When aniline is passed with hydrogen over reduced nickel[9] heated to 190° ammonia is evolved, and there are formed in nearly equal amounts cyclohexylamine $C_6H_{11}.NH_2$; dicyclohexylamine $C_6H_{11}.NHC_6H_{11}$, and cyclohexylaniline $C_6H_5.NH.C_6H_{11}$. Diphenylamine gives, under similar conditions, a mixture of cyclohexylaniline, dicyclohexylaniline, and small amounts of benzene, aniline, and cyclohexylamine. If the tempera-

[1] *Compt. Rend.*, 1903, **137**, 1025.
[2] *Rec. Trav. Chim.*, 1905, **24**, 19.
[3] *Compt. Rend*, 1903, **137**, 1025.
[4] Markownikoff and Stadnikoff, *J. Russ. Chim. Soc.*, 1903, **35**, 389
[5] Stadnikoff, *ibid.*, 1904, **36**, 485.
[6] Sabatier and Mailhe, *Compt. Rend.*, 1904, **138**, 1321.
[7] *Ibid.*, **140**, 350.
[8] Brunel, *Bull. Soc.*, 1905 (3), **33**, 271.
[9] Sabatier and Senderens, *Compt. Rend.*, 1904, **138**, 457.

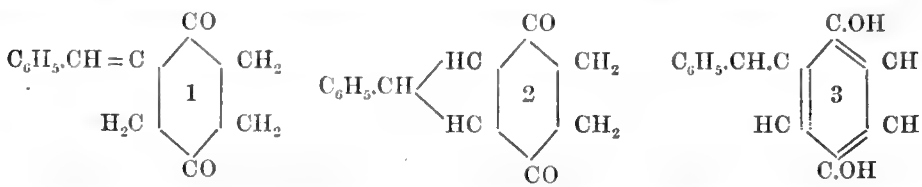
ture be increased to 250°, diphenylamine is completely broken down into ammonia and hexahydrobenzene.

At temperatures of 160° to 180° the methyl and ethyl anilines[1] are readily converted into hexahydro-derivatives without the formation of any condensation products, though small quantities are decomposed into hexahydrobenzene and a fatty amine. At higher temperatures the reaction is much more complicated.

The preparation and properties of cyclohexyl- mono- and diethylamines, and of cyclohexyl- mono- and dimethylamines are described.

The hydrogenation of *m*-toluidine, which takes place with difficulty at all temperatures, probably because the products are difficultly volatile, gives at 200° a mixture of hexahydro-*m*-toluidine, dimethylcyclohexylamine and methylcyclohexylaniline.

Ketones.—1 : 4-diketohexamethylene[2] condenses with benzaldehyde under the influence of hydrogen chloride to form benzylhydroquinol (3), which may be formed by the rearrangement of the benzylidene derivative (1)



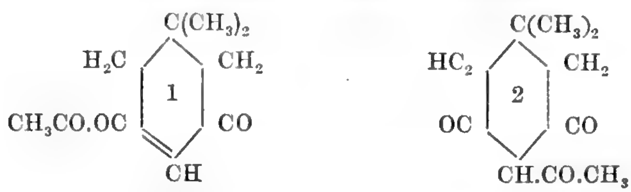
or of the norcaran derivative (2). On oxidation with chromic acid it gives benzylquinone. Anisaldehyde gives similar derivatives.

Biltz[3] has shown that by chlorinating *o*- and *p*-hydroxybenzaldehyde chlorinated ketotetrahydrobenzenes are obtained.

1-keto-3-methylhexahydrobenzene gives on treatment with sodamide[4] a sodium derivative, which reacts with alkyl iodides to give 1-keto-3-methyl-6-alkylhexahydrobenzenes. All the ketones described give benzylidene derivatives, which on oxidation with potassium permanganate in acetone solution give the corresponding α-methyl-α'-alkyladipic acids. Alcohols have been prepared from the above ketones by reduction with sodium in alcoholic solution.

3-keto-4-benzyl-1-methylhexahydrobenzene and 3-keto-2 : 4-dibenzyl-1-methylhexahydrobenzene.[5]

Dieckmann and Stein[6] have been led to the conclusion that the formation of C-acetyl derivatives of 1 : 3-dicarbonyl compounds by the action of acetic anhydride, only takes place under the influence of condensing agents ; *e.g.*, dimethyl- and phenyldihydroresorcins with acetic anhydride alone give their O-acetyl derivatives (1), which are neutral bodies, not giving a colour reaction with ferric chloride, and very readily decomposing into acetic acid and substituted dihydroresorcin.



[1] Sabatier and Senderens, *Compt. Rend.*, 1904, **138**, 1257.
[2] Stollé and Moering, *Ber.*, 1904, **37**, 3486.
[3] *Ber.*, 1904, **37**, 4003.
[4] Haller, *Compt. Rend.*, 1905, **140**, 127.
[5] Haller, *Compt. Rend.*, 1905, **140**, 624.
[6] *Ber.*, 1904, **37**, 3370.

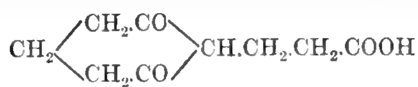
On the other hand, with acetic anhydride in presence of only traces of alkali C-acetyl derivatives are formed (2). In contradistinction to the O-acetyl derivatives, these bodies have marked acid properties, and give an intense ferric chloride reaction. On boiling with mineral acids they are decomposed into acetic acid and substituted dihydroresorcin, and oxidation with sodium hypobromite converts them into substituted glutaric acids.

O-acetyl derivatives are converted into C-acetyl derivatives by heating with acetic anhydride and a trace of alkali.

The possibility of using condensing agents other than alkali has been experimented on, and it is shown that dimethylaniline and quinoline produce O-acetylation; pyridine and tripropylamine produce C-acetylation, and concentrated sulphuric acid principally C-acetylation, but to a small extent O-acetylation.

Acids.—The fractions obtained in the distillation of petroleum may be converted into the corresponding carboxylic acids[1] by chlorinating, adding magnesium and a catalytic agent, passing a current of carbon dioxide, and decomposing the complex magnesium compound thus obtained. The method is more particularly applicable for the preparation of fatty acids, but the fraction boiling at 80° to 82° yields pure hexahydrobenzenecarboxylic acid, and the fraction 71° to 79° this same acid mixed with methylcyclopentanecarboxylic acid.

When acetonedipropionic acid[2] $CO(CH_2.CH_2.CH_2.COOH)_2$, obtained by the hydrolysis of ethyl ketoheptanetetracarboxylate, is heated, water is eliminated and dihydroresorcinpropionic acid results. It possesses all



the characteristics of the dihydroresorcin derivatives.[3]

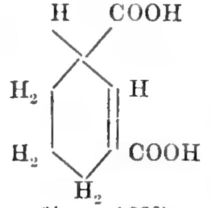
Following von Baeyer's directions[4] for the reduction of phthalic acid, Abati and Bernardinis[5] have isolated three new substances, namely, *cis*-Δ^2-tetrahydrophthalic anhydride, $\Delta^{1:3}$-dihydrophthalic anhydride, and a substance M.P. 174°, which is most probably a dihydrophthalic acid.

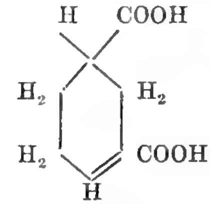
Von Baeyer has shown[6] that the reduction of isophthalic acid takes place with much greater difficulty than in the case of phthalic or terephthalic acids. He obtained an acid melting at 199° which agreed on analysis with a tetrahydroisophthalic acid. In 1891 Perkin[7] synthesised the *cis*- and *trans*-modifications of hexahydroisophthalic acid, and shortly afterwards Baeyer and Villiger[8] obtained these same *cis*- and *trans*-acids by the direct reduction of isophthalic acid.

Perkin and Pickles[9] have now obtained all four possible tetrahydroisophthalic acids also by direct reduction of isophthalic acid, and for reasons given in the original paper these authors conclude that the con-

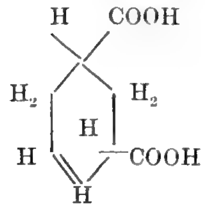
[1] Zelinsky, *D. R. P.*, 151880.
[2] Von Pechmann and Sidgwick, *Ber.*, 1904, **37**, 3816.
[3] Compare Merling, *Annalen*, 1894, **278**, 20, and Vorlaender, *ibid.*, 1897, **294**, 270.
[4] *Annalen*, 1890, **258**, 199.
[5] *Cent. Blatt.*, 1905 (1), 1318.
[6] *Ber.*, 1886, **19**, 1806.
[7] *J. C. S.*, **59**, 808.
[8] *Annalen*, 1893, **276**, 255.
[9] *J. C. S.*, 1905, **87**, 293.

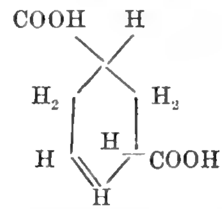
stitutions of the four isomerides are most probably represented by the following formulæ :—





Δ^2(m.p. 168°) Δ^3(m.p. 244°)

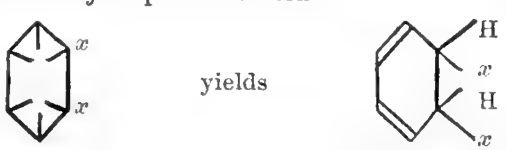




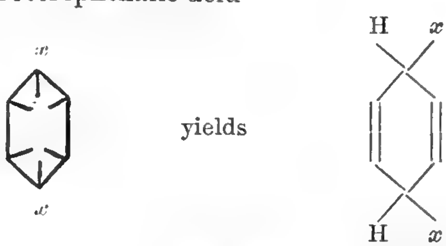
cis Δ^4(m.p. 165°) trans H^4(m.p. 227°)

It has not been found possible to isolate even a trace of a dihydroisophthalic acid from the reduction products, though von Baeyer has shown that the products first formed on reduction of phthalic and terephthalic acids are always dihydro derivatives. The following considerations are suggested as supplying a reason for this curious difference in the behaviour of isophthalic acid.

In the reduction of phthalic and terephthalic acids hydrogen atoms always attach themselves in the first instance to the carbon atoms which carry the carboxyl groups. Thus the first product of the reduction of phthalic acid is $\Delta^{3:5}$-dihydrophthalic acid—



and, in a similar manner, the first product of the reduction of terephthalic acid is $\Delta^{2:5}$-dihydroterephthalic acid—

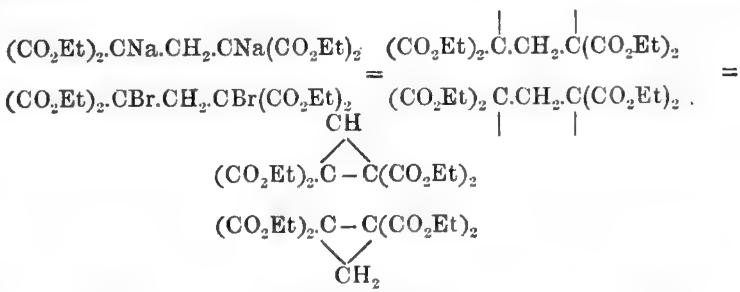


If this process be applied to isophthalic acid, it leads to the following unsaturated scheme :—

in which the valencies are unable to unite to form double linkings, as in the case of dihydrophthalic and dihydroterephthalic acids.

This argument may account for the difficulty experienced in reducing isophthalic acid, and for the fact that tetrahydro derivatives, and not dihydro derivatives, are formed at once, because the free valencies, which cannot saturate one another, will naturally combine with hydrogen, and thus yield at once tetrahydroisophthalic acids.

The substance[1] derived from the condensation product of ethyl dibromopropanetetracarboxylate and ethyl disodiopropanetetracarboxylate is not, as described in the last report,[2] a mixture of trans-hexahydrobenzenetetracarboxylic acid and the double anhydride of the *cis*-modification of the same acid, but is a mixture of *cis*- and *trans*-trimethylenedicarboxylic acid. The condensation takes place in accordance with the following scheme:—



Rosaniline Bases.—The trihydrochlorides of the rosaniline bases combine with four molecules of water[3] in acid solution to form tetrahydroxyhexahydrobenzenerosanilines, analogous to the tetrachloro- and tetraminohexahydrobenzenerosanilines previously obtained by absorption of 4HCl or $4NH_3$. To account for the formation of colourless solutions under the above conditions[4] it is assumed that four molecules of water are taken up, the quinonoid nucleus being transformed into a cyclohexane ring, which view is supported by thermo-chemical data.

The Nature of Double Linkings.—From the observations of others on the addition of bromine to unsaturated substances,[5] Bauer is led to the following generalisations, which, though not drawn up with special reference to hydro-aromatic substances, may be of use to those working in this field.

The capability of carbon atoms, united by a double bond, adding on bromine is lessened when both carbon atoms have attached to them the following groups: COOH, COOR, C_6H_5 or Br. In certain cases alkyl residues in combination with the above groups behave in a similar manner. In the system $R^1R^2C{=}CR^3R^4$, if R^1 be replaced by COOH, bromine is added on so long as $R^2R^3R^4$ are not replaced by bromine or bromine and methyl. Methyl groups without bromine atoms have no influence. For example, addition takes place in the case of acrylic, bromo- and dibromoacrylic crotonic, dimethyl- and trimethylacrylic acids, but not with tribromoacrylic or dibromocrotonic acids.

When R^1 and R^3 are replaced by carboxyl groups, the addition takes place so long as R^2 and R^4 are not both replaced by Br or methyl: for example, fumaric, methylfumaric and bromomaleic acids form dibromides, whereas dibromo- and dimethylfumaric acids do not.

If R^1 be replaced by C_6H_5 and $R^2R^3R^4$ by methyl groups, addition takes place; but if R^1 and R^3 are replaced by C_6H_5 and R^2 and R^4 by

[1] Perkin, *J. C. S.*, 1905, **87**, 358.
[2] *Reports*, 1904, p. 62.
[3] Schmidlin, *Compt. Rend.*, 1904, **139**, 506.
[4] *Ibid.*, p. 521.
[5] *Ber.*, 1904, **37**, 3317.

bromine atoms, no addition is possible. With R^1 and R^2 both C_6H_5 groups, the replacement of R^3 or R^4 by bromine is sufficient to prevent addition of bromine, but not if R^3 or R^4 or both be replaced by methyl. As examples, stilbene, methylstilbene, bromostilbene and diphenylethylene add on bromine, but dibromostilbene and diphenylbromoethylene do not.

Investigation of the Fossiliferous Drift Deposits at Kirmington, Lincolnshire, and at various localities in the East Riding of Yorkshire.—Report of the Committee, consisting of Mr. G. W. LAMPLUGH (*Chairman*), Mr. J. W. STATHER (*Secretary*), Dr. TEMPEST ANDERSON, Professor J. W. CARR, Rev. W. LOWER CARTER, Mr. A. R. DWERRYHOUSE, Mr. F. W. HARMER, Mr. J. H. HOWARTH, Rev. W. JOHNSON, Professor P. F. KENDALL, Mr. H. B. MUFF, Mr. E. T. NEWTON, Mr. CLEMENT REID, *and* Mr. THOMAS SHEPPARD.

THE last report of the Committee (Cambridge, 1904) described the completion of successful work at Kirmington and at Limber, Lincolnshire. Since then the Committee have commenced operations at two localities in the East Riding of Yorkshire, viz., Bielbecks and Speeton; but owing to the early date at which this report has to be rendered, and to other circumstances, it has been found impossible to send in a report of completed work at either of these places.

Bielbecks.—This place is situated in the Vale of York, two miles south of Market Weighton and one mile north-west of North Cliff. Between seventy and eighty years ago a rich deposit of mammalian and other remains was accidentally discovered here, and were subsequently described in the 'Philosophical Magazine,' September 1829, by the Rev. W. V. Harcourt. A large number of specimens were obtained, the bulk of which are, we believe, in the museum at York. The deposit is obviously a very important one, and it has long been felt that, if possible, more information as to its precise nature should be obtained. With this object in view your Committee have put down borings, and have been able to locate the black marl which is believed to contain most of the bones and shells. Later in the year—probably in July—it is intended to make a large excavation of which a detailed report will be prepared and presented at the York meeting in 1906.

The 'Speeton Shell Bed.'—This bed was seen by Professor Phillips in the year 1855, and a brief account of it occurs in his 'Geology of Yorkshire,' vol. ii. The bed was described more fully by Mr. G. W. Lamplugh in the 'Geological Magazine' (1881, p. 176). Since then the bed has become much obscured by slips. As the relationship of this bed to the glacial drift is still a debatable matter, your Committee decided that the bed came within the scope of their investigations. With the assistance of Mr. C. G. Danford, of Reighton, an excavation has been made, and a clean section down to the base of the shell bed obtained. The details, however, have still to be worked out.

The thanks of the Committee are due to W. H. Fox, Esq., for permission to excavate at Bielbecks, and also to the Right Hon. the Earl of Londesborough for permission to investigate the shell bed at the base of the drifts at Speeton.

The Committee request to be reappointed, with power to use the unexpended balance of last year's grant.

Investigation of the Fauna and Flora of the Trias of the British Isles. Third Report of the Committee, consisting of Professor W. A. HERDMAN (*Chairman*), Mr. J. LOMAS (*Secretary*), Professor W. W. WATTS, Professor P. F. KENDALL, *and* Messrs. H. C. BEASLEY, E. T. NEWTON, A. C. SEWARD, *and* W. A. E. USSHER. (*Drawn up by the Secretary.*)

THE work of the Committee during the past year has been mainly directed towards ascertaining what Triassic fossils are stored in provincial museums.

Circulars have been issued asking for information, and casts of typical footprints have been distributed as an aid to identification.

Numerous replies have been received, but a more critical examination of the specimens is desirable in many cases, and it is hoped to incorporate the results in next year's report.

Other lines of research are in progress, including a detailed description of the footprints found in the Upper Trias by Mr. H. C. Beasley ; and a careful examination of the Rhynchosaurus remains in the Shrewsbury Museum is being made by Dr. A. Smith Woodward.

The Museum Committee of the Shrewsbury Town Council has kindly allowed the valuable slabs in their keeping to be sent to the British Museum for this purpose.

The present report includes a list of Triassic fossils from the Bath Museum, by the Rev. W. H. Winwood, M.A., F.G.S. ; from the Warwick Museum, by Mr. H. C. Beasley ; and, by the kindness of Mr. W. A. E. Ussher, F.G.S., of the Geological Survey, an original section, drawn and coloured by the late Mr. P. O. Hutchinson, is reproduced, showing the relative positions of the beds in the Sidmouth area, in which plant and saurian remains have been found. A short note on the occurrence and habitat of *Estheria minuta* is also contributed by the Secretary.

List of British Triassic Fossils in the Moore Collection, Bath Museum. By the Rev. H. H. WINWOOD, *M.A., F.G.S.*

Name.	Formation.	Locality.
	PLANTÆ.	
Undetermined sp. . . .	Keuper . .	Burtle Heath.
	CRUSTACEA.	
Estheria minuta, Alberti . .	Keuper . .	Near Somerton.
	PISCES.	
Diplodus moorei, A. S. Woodward. The type teeth decribed and figured by A. S. Woodward, 'Ann. and Mag. Nat. Hist.' [6] vol. iii. (1889), p. 299, Pl. XIV. figs. 4, 5.	Keuper . .	Ruishton, near Taunton.
Acrodus (?) *keuperinus*, Murch. and Strickl. sp.; teeth, dorsal fin-spines, and cephalic spines (Sphenonchus).	Keuper . .	Ruishton, near Taunton.
	REPTILIA.	
Thecodontosaurus (teeth) . .	Keuper . .	Bristol.
Rhynchosaurus articeps, Owen; vertebræ only	Keuper . .	Grinshill, Shropshire.

Notes on Footprints from the Trias in the Museum of the Warwickshire Natural History and Archæological Society at Warwick. *By* H. C. Beasley.

The Warwick Museum contains about fifty slabs of sandstone of various sizes, showing either casts or impressions of footprints. About fifteen of them are from the Upper Keuper sandstone of Shrewley, Warwickshire.

From the Lower Keuper there are nine, mostly large ones, from Lymm, Cheshire, two or three from Grinshill, Salop, and one large one and several smaller ones from South Staffordshire, one large one from Coten-end, Warwick, and several from both Upper and Lower Keuper in other localities in the Midlands. Besides these there are others which have lost their labels, but of which it is possible to guess the locality.

From this it will be seen that the collection gives an opportunity for comparing the indications of the fauna in a variety of localities and of different horizons.

The portion of the collection of most interest is that obtained from the Upper Keuper sandstones of Shrewley. The quarry by the side of the canal is, unfortunately, not now worked, and is covered with a dense growth of vegetation, but whilst it was open it appears to have been closely watched by the Rev. P. B. Brodie, and other Warwick geologists, who secured a good number, not only of footprints, but of fossil remains.

The beds of sandstone are intercalated in the Keuper marls, and were described in 1837 by Murchison and Strickland, and some fossils and a large slab of footprints figured.[1]

The sandstones consist of thin beds, in all 8 or 10 feet, underlain by tea-green marl. Besides footprints, fish and other organic remains have been found in the sandstones, and *Estheria minuta* is common both to the sandstones and the marls. A bed, apparently immediately below the sandstones, has yielded several species of mollusca, recorded in the reports of the specimens in the British Museum, Natural History, and the Geological Survey Museum, in this Committee's report of last year, by Dr. A. S. Woodward, F.R.S., and Mr. E. T. Newton, F.R.S.

The slab which is figured with the paper by Murchison and Strickland, referred to above, is in the Warwick collection, and the prints, in relief, are still quite recognisable. They are described in Part ii. of this report (p. 278, 1904) as D 4. The manus has the digits free, with no trace of webbing, and they look slender and weak compared with those of the larger pes, which, as before described, is distinctly webbed. There is a distinct track of a tail between the two rows of the footprints. The large

[1] *Trans. Geol. Soc.*, 2nd series, vol. v. p. 339, and Plate XXVIII. 'On the Upper Formation of the New Red Sandstone System in Gloucester, Worcestershire, and Warwickshire, showing that the Red, or Saliferous Marls, including a peculiar Zone of Sandstone, represent the Keuper or "Marnes irisées" with Some Account of the Underlying Sandstone of Ombersley, Bromsgrove, and Warwick, Proving that it is the Bunter Sandstein, or Grès Bigarré of Foreign Geologists,' by R. I. Murchison, V.P.G.S., and H. S. Strickland, F.G.S., read June 14, 1837.

The section is also described in *Quart. Jour. Geol. Soc.*, vol. xii. p. 374. 'On the Upper Keuper Sandstone (included in the New Red Marl) of Warwickshire,' by the Rev. P. B. Brodie, M.A., F.G.S., read June 4, 1856; also *Quart. Jour. Geol. Soc.*, vol. xiii. p. 574, and vol. xiv. p. 165, by the same.

label attached reads, 'Footsteps of Labyrinthodon, Upper Keuper, Shrewley, presented by Hugh E. Strickland, Esq., F.G.S.' The prints are, however, decidedly Rhynchosauroid in form. There do not seem to be quite similar prints on any of the other slabs from Shrewley.[1]

The most common is another Rhynchosauroid form which is distinguished from the foregoing by the absence of webbing and by the club-shaped digits, which show no trace of the presence of a nail. The digits are narrow at the proximal joint and gradually widen towards the distal end, where they are clearly rounded off. They are of the same proportional lengths as those of the other Rhynchosauroids, are moderately divergent, and the print of the fifth digit is only occasionally shown. In one case it is distinctly marked on both pes and manus. The other digits, I-IV., are usually fairly marked. This form will be referred to as D 6; it is a distinctly Shrewley form. Several examples are on small pieces of stone in one of the upright cases, and are described as Labyrinthodon on the labels. There are a pair of slabs, relief and impression, on the wall, with traces of two pairs of feet of this form on a rippled surface. These are also labelled as 'Labyrinthodon.' (These are just to the left of the slab next to be described.) The slabs are about 8 inches across.

Another, immediately to the left of the Murchison and Strickland slabs, measures about 15 inches and 13 inches, and shows a number of impressions on a rippled surface of fine white sandstone. It is labelled

Name	Footprints of Labyrinthodon
Locality	Shrewley
Donor	Rev. P. B. Brodie

There are portions of the surface of two layers, with footprints on each. The upper one is very thin, and the ripples are continuous on each. The ripples are much flattened, and it is doubtful if they are actual ripple marks, or if they may not have been due to other causes. They, however, do not interfere with the definition of the footprints, which apparently were made subsequently.

The footprints are decidedly Rhynchosauroid, and are mostly D 1. Besides footprints there are what appear to be the tracks of Gasteropods, but might possibly be due to the tails of reptiles, though no connection with the footprints is apparent, as was the case in the slab described above. Altogether this slab is a most interesting one, and will repay further study and comparison with others of the same character in the collection.

To the left of this is a large slab showing a series of prints of Cheirotheroid character. Unfortunately they are very imperfect, only the termination of three or four digits being recognisable on each foot. The breadth of the print is 6 inches; the length is not determinable. It is very uncertain whether very indistinct markings a little in advance of the more distinct prints represent the forefeet, but they possibly do. The Cheirotheroid prints usually are found in linear arrangement, the left

[1] There is a slab of similar stone, in a very dark corner and close to the ceiling, with imperfect *impressions* of somewhat the same form as the Murchison-Strickland slab. It hardly corresponds sufficiently to be the counterpart, which, moreover, in the original paper is said to have been deposited in the Museum of the Geological Society. The present position of this slab renders a careful examination very difficult.

feet being in a line with the right (see Part i. 1903, p. 224), but in this case the track is fully 9 inches between the line of the middle digits of the right and left feet. This might be caused by the animal being in the act of turning, but the direction of the digits shows no sign of this.

There is a marking, extending obliquely across the lower part of the slab, which might at first sight be taken for the track of the tail of the animal whose footprints it accompanies. It is $1\frac{1}{2}$ inch wide and of a flattened cylindrical form, continuing nearly the same width throughout the length (about 2 feet) preserved. Longitudinal ridges, flat and in very low relief, are plainly discernible, as are also what appear to be the attachments of leaflets or small branches. The impression being cut off at either end by the margin of the stone, there is no trace of its natural termination.

On two other slabs in the Museum there are markings that may be considered in connection with this—the first on a large slab labelled 'Slab of Keuper Sandstone with Impressions of Plants upon it, from Coten End Quarry, 1872'—(this quarry is in the Lower Keuper Sandstone, near the Great Western Goods Station, Warwick. It is not being worked at present). On this (which is $2' \, 9'' \times 3' \, 6''$) are some markings longitudinally ribbed and like that described above, but terminating in narrow rods which look like continuations of the longitudinal ribs; there are branched markings near each side of the main stem (?) There are no distinct footprints on this slab. Somewhat similar markings associated with footprints are also seen on a slab from Lymm, Cheshire, labelled 'Footprints of Cheirotherium, Lymm, Cheshire, Richd. Corbet, Esq.' On this slab are the manus and part of pes of A (probably A2), and below are some similar (though slightly smaller) markings to those described, with traces of narrow leaflets; the ribs and rod-like termination are fairly clear.

An inorganic origin of these markings, such as running water, might be suggested were it not for a specimen from Storeton in the British Museum, Natural History, R 730, which has all the features of those above described, but the main part of the marking is covered with rows of distinct scales corresponding with the longitudinal ribs on those just described.[1]

The Footprints from Lymm.—There are a number of fairly large slabs from Lymm, Cheshire, but the prints upon them are all more or less imperfect, and in many cases have been chipped in the quarrying. Nearly all the prints are of the Cheirotheroid form, A 2; the most interesting is that with supposed plant remains described above.

Two or Three Slabs from Grimshill.—One is a strongly ripple-marked slab labelled 'Footprints of Rhynchosaurus, New Red Sandstone, Lower Keuper Grinshill, presented by Sir Vincent Corbet, B.A.'; a second label in Rev. Mr. Brodie's writing runs, 'Footprints of Rhynchosaurus Articeps, Grinshill, Salop.' There are numerous very imperfect prints, mostly only raised oval patches, about an inch across, and none of them showing detail. Besides the oval marks there is a print of three digits with the nails turned to one side and in every way resembling the three longer digits of a large D 1.

Another print from Grimshill is in one of the glass cases. On it are

[1] For figure and description see Morton's *Geology of Liverpool*, Appendix, p. 300, Pl. XXII.

two footprints in relief; one is very imperfect, the other the print of such a foot as, when rather clogged with mud, might have made the oval marks on the slab last described. It shows three very distinct claws and no clear division between the digits, which must have been short. The breadth of the print is 2·5 cm., and the length very slightly more. It bears some resemblance to the print in the Chester Museum described in Part ii. 1904, page 281, as I, but the breadth of the foot is greater, and there is a very slight indication of the print of the first digit. It is labelled, 'Rhynchosaurus, Grinshill, Salop.'

South Staffordshire.

A large slab of red sandstone about 2 feet square, the first on the left of the lower row, is labelled 'Footprints of Rhynchosaurus Articeps, Owen, from Corven Burwood, near Wolverhampton, Lower Keuper Sandstone (Waterstones), Rev. F. Catt.' This is evidently from Coven, Brewood, Staffordshire, a locality that has contributed very similar slabs also to the British Museum, Natural History, the Liverpool and the Worcester Museums. All of them are, unfortunately, so crowded with prints that it is difficult to recognise any as even fairly perfect. They are undoubtedly Rhynchosauroid and probably D 3. The surface represented by the slabs in the museums mentioned, which look as if they all came from the same bed, must have been many square yards in extent, and the crowded state of the prints points to the presence of a very large number of individuals.

In the glass case before referred to as containing some smaller specimens of footprints is a small piece of chocolate-coloured sandstone, with prints of fore and hind feet of D 3, slightly smaller than those in the large slab. It is labelled 'Rhynchosaurus, Brewood, Staffordshire, Rev. P. B. Brodie.' The print and the matrix are almost identical with those found by Mr. Beeby Thompson, F.G.S., in the same district.[1]

Another small slab from Brewood has a Cheirotheroid print not quite perfect, but apparently of A 2 form.

Among those without labels is a footprint (impression) in very white sandstone, a little to the right of the large Brewood slab. The print in size almost equals A 3 *Cheirotherium Herculis*, but in form it more resembles A 1 *C. Stortonense*; the digits are rather long and taper to quite a fine point.

Only a small proportion of the footprints have been mentioned, but the whole collection is of great interest, and the presence of footprints from Henley-in-Arden and Preston Bagot shows that the exposures of footprint beds are not restricted to a small area.

From the latter place, Preston Bagot, there is an imperfect A form, with short stout digits, probably of A 2, with a slight trace of the forefoot. This is labelled 'Labyrinthodon Footsteps, Upper Keuper Trias, Preston Bagot, purchased.'

This report has confined itself to the footprint slabs, but the Museum collection includes a number of vertebrate and invertebrate fossils and plant remains from the Trias of the district, which we must hope will be recorded elsewhere.

[1] See B.A. Trias Report, Part ii., 1904, p. 277. Also *Geological Magazine*, May 1902, by Dr. A. S. Woodward.

The collection also includes *plaster casts* of one of the Bootle foot-print slabs, and another of sundry prints, not named, and of *Equisetum Keuperina*, which does not in any way resemble the plant impressions alluded to in the report.

Note on the Occurrence and Habitat of Estheria *in the Trias of Britain. By* THE SECRETARY.

The conditions under which the Triassic rocks of Great Britain have been laid down have long been a matter of dispute. They have been claimed as marine, lacustrine, and fluviatile deposits by various workers, but in each case it has been found that serious difficulties stood in the way of the acceptance of any one of these methods of accumulation.

In recent years the idea has been steadily gaining in strength among geologists that the action of wind in a desiccated region will best explain the peculiar features which the Triassic rocks exhibit. It has never been denied that water has played an important part in their deposition, but this seems to have been of an inconstant nature, like the temporary streams and lakes which appear for a time in the deserts of to-day and then disappear by evaporation or other causes.

The problem has almost invariably been approached from the physical standpoint, and but little attention has been paid to the palæontological side of the question.

This is doubtless due to the fact that the fossil contents of the Triassic rocks are few in number and difficult to understand, features they possess in common with the fauna and flora of existing deserts.

The little Phyllopod crustacean, *Estheria minuta*, is by far the most common, the most widely distributed, and the most characteristic fossil of the Triassic period, and an examination of the beds in which it is found, the fossils with which it is associated, and the conditions under which its congeners of the present day exist, may help towards a better understanding of the problem stated above.

We owe most of our knowledge of fossil Estheria to Professor Rupert Jones, F.R.S., whose monograph in the Palæontographical Society's 'Proceedings' (1862), and subsequent papers published in the 'Geological Magazine' and other journals, have furnished most of the materials for this note.

Only one species, *Estheria minuta*,[1] Alberti, has been found in the British Trias, and one variety, *Estheria minuta*, var. *Brodieana*, formerly thought to be limited to the Rhætic.

With the exception of some specimens found by Mr. C. E. de Rance in the Lower Keuper of Alderley Edge, Cheshire, and recorded in last year's report,[2] all the British specimens of *Estheria minuta* have been obtained from the Upper Keuper.

In the European Trias it occurs in the Lower Bunter of Eastern France, the Upper Bunter of Baden and Hanover, the Muschelkalk of Baden and Thuringia, the Lettenkohle of Eastern France, Baden, Hanover and Thuringia, the Lower Keuper of Thuringia, and the Upper Keuper of Würtemberg and Hanover.

It ranges, then, through all the members of the Triassic series from top

[1] *Monog. Palæ. Soc.*, 1862, p. 57, Pt. ii.; *Geol. Mag.*, 1898, p. 292, fig. 3.
[2] B.A. Trias Report, Pt. ii. p. 277

to bottom, and it probably only needs careful search to extend its range in the British rocks.

Until recently *Estheria minuta*, var. *Brodieana* was considered as characteristic of the Rhætic. It occurs in a certain zone of this series in Gloucestershire, Worcestershire, Warwickshire, Somersetshire, and Morayshire, and is so plentiful that it has been described as forming thin limestones.

However, in 1900 several specimens, identified by Professor Rupert Jones, were found in the Keuper marls at Oxton, Cheshire,[1] and its range has thus been extended into the Keuper proper.

Habitat of Recent Estheria.

More than twenty species are known to exist at the present time. We find them in freshwater pools, Strasburg ; brackish water marshes, Arzeu, near Oran, Africa ; in ditches filled with rainwater, Toulouse, Tunis, and Algeria ; in freshwater marshes of the Island of Dahalac, on the coast of Abyssinia ; in stagnant water on the banks of the Tigris, near Bagdad ; in rainwater pools, Malta ; in freshwater streams near Nagpur, India ; in rainwater pools on limestone near Jerusalem, dry for ten or eleven months in the year ; in a dried-up 'vley' near Port Elizabeth, South Africa ; in brackish water in Cuba and Cape of Good Hope, and in Lake Winnipeg.

One species, *Estheria Giboni*, from a freshwater pool of Gibon, Jerusalem, was reared in England by Mr. H. Denny and Dr. Baird from the dry mud brought from the Pool of Gibon.

Thus we see that the genus has a wide distribution ; it lives in fresh, stagnant, or brackish water ; it is capable of existing under great extremes of heat and cold, and in regions subject to great desiccation.

According to Professor Rupert Jones, recent *Estheriæ* appear, as it were, suddenly (like the *Apus*) in pools and ditches, and are quickly developed in tanks and ponds dry for even ten or eleven months in the year.

Habitat of Fossil Estheriæ.

Fossil Estheriæ have been found in the Old Red formation, and in almost every subsequent freshwater deposit up to the present day.

They are constantly associated with other freshwater crustacea, freshwater molluscs, fishes, reptiles, insects, and plants. Occasionally dwarfed marine shells are found, indicative of brackish conditions.

No truly marine organisms have ever been found associated with them in the same bed.

Dealing specially with *Estheria minuta*, we find it to occur principally in the so-called marls and clays of the Trias series, and less frequently in sandstone.

Professor Rupert Jones[2] remarks that the Estheriæ of the Keuper might have been at once regarded as of equally freshwater habits with their recent congeners were it not that the salt condition of the waters depositing much of the Keuper sandstones and shales is proved by the masses of rock-salt and by the casts of the cubical crystals of salt occurring

[1] Lomas, 'On the Occurrence of Estheria and Plant Remains in the Keuper Marls at Oxton, Birkenhead.' *Proc. Liverpool Geol. Soc.*, 1901, p. 77, Pl. IV.

[2] *Monog. Palæ. Soc.*, 1862, p. 65.

abundantly in the same beds. Still, he acknowledges that, in his experience, Estheriæ have not been found in these salt-bearing beds, but appear to keep a definite line above the horizon of the rock-salt, and beneath that of the salt pseudomorphs.

In this he appears to have been mistaken, for the Oxton specimens show Estheria, plant remains and salt pseudomorphs on the same surface, and the occurrence of the fossil in the Lower Keuper brings it below the salt-bearing beds.

But does it follow that the presence of salt necessarily implies marine conditions? We find salt in plenty covering the floors of the dried-up 'vleys' of South Africa. Some of these are situated in the High Veldt, thousands of feet above sea-level. They are fed by streams during the rainy season, and the salt represents the material brought by these streams into the vleys after the water has evaporated. Living Estheriæ, are found in these 'vleys.' A sample of mud I collected in a salt-pan near Riverton, South Africa, was simply swarming with them.

Another suggestive fact is that plant remains are almost invariably associated with fossil Estheriæ. They are mostly fragmentary and evidently drifted.

A careful study of the 'vleys' and salt-pans in South Africa might yield very important clues as to the origin of the Trias. They are shallow hollows in a vast plain covered with loose sand and supporting only a scanty xerophytic vegetation.

When rain falls, streams flow along temporary channels or over the ground, without any defined channel, towards the vleys. All traces of the channels worn out by the stream may be lost before the next rainy season, for in the dry season winds drift the loose sand, filling up old hollows and making new ones.

In the vleys themselves the water evaporates and various salts brought down in solution are left as residues.

It is in the muds and sands thus impregnated with salts that Estheria flourishes. The vleys support but little vegetation, but the streams carry with them the stems, leaves, and seeds of plants, and these become entombed in the muds along with the crustacea living there.

Thus almost every feature reproduces the exceptional and puzzling features of the Upper Trias rocks of England, and a consideration of the habitat of *Estheria minuta*, especially if taken in connection with that of recent species, lends additional support to the suggestion that the Triassic rocks of Britain and in some parts of the Continent are the products of desert or semi-desert conditions.

Geological Section of the Cliffs to the West and East of Sidmouth, Devon. By P. O. Hutchinson, *Sidmouth, Devon, October* 8, 1878.

Explanation and Notes on Section (fig. 1).

A. *Salt Band.*—At the point A′ in the salt band, under Wind Gate, Mr. W. A. E. Ussher first detected the pseudomorphous crystals of salt. They had before been only known in Salcombe Hill, where the salt band strikes the beach.

B. *Carbonate of Lime Band with Potato Stones.*—The potato stones are hollow nodules of crystallised carbonate of lime. The whole series of beds may amount to 40 or 50 feet in thickness.

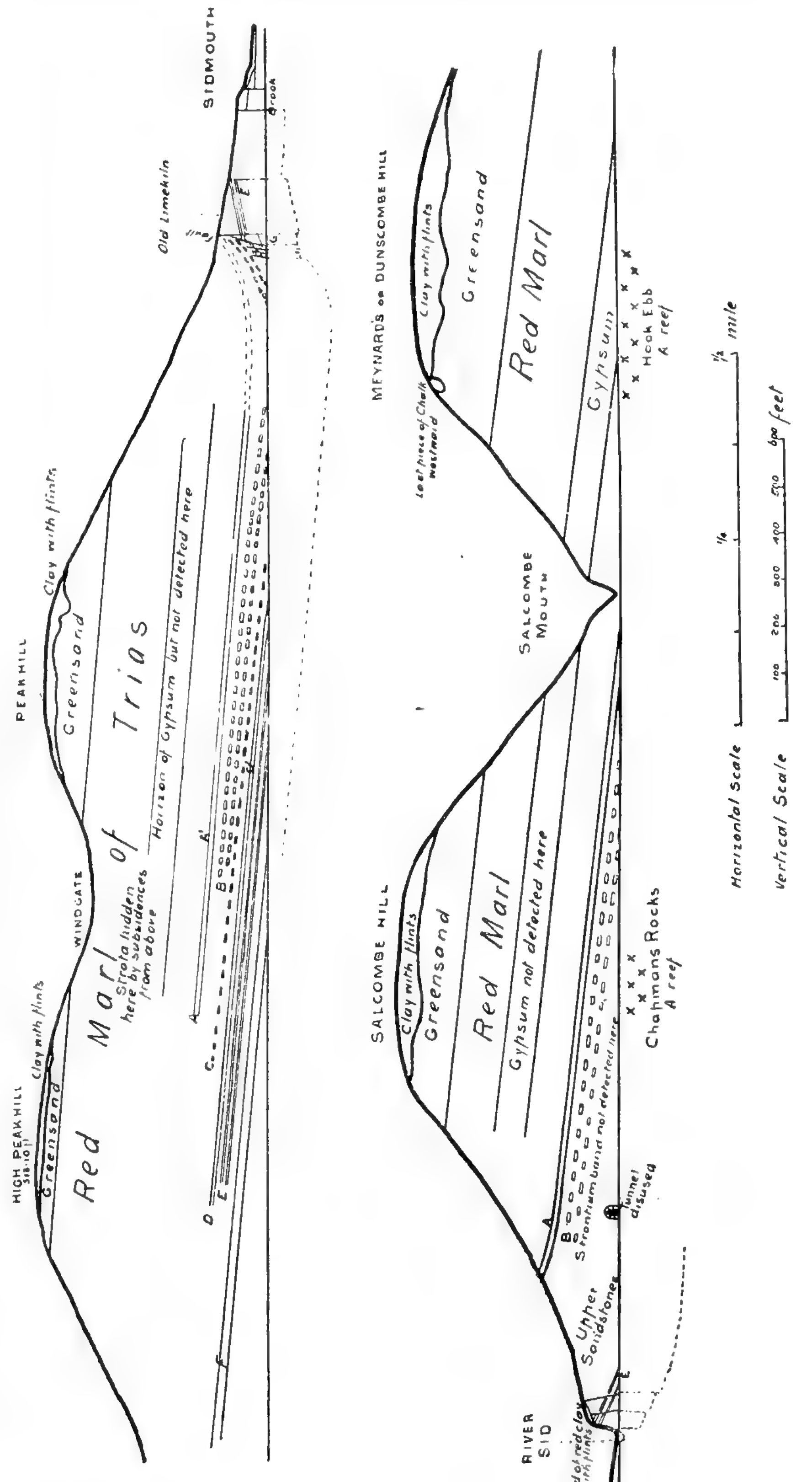


FIG. 1.—Geological Section of the Cliffs to the West and East of Sidmouth, Devon.

C. The stratum of nodules containing crystals of sulphate of strontium upon the crystals of carbonate of lime occurs towards the lower part, and at about 14 feet above the white bands.

D. The stem of a lacustrine plant, not yet named, was discovered by a fall of the cliff at D′. The real size is 1 inch to $1\frac{1}{4}$ inch in diameter. The side stems (none preserved) were about as thick as a quill pen. The joints occur every 6 to 8 inches. The substance of the interior is soft sandstone, the exterior a film of clay greenish in colour. Eight or ten side branches grow out at each joint.[1]

E. *White Bands.*—I merely mention these for the purpose of fixing levels on each side of the valley. Just above this level the marl passes into sandstone. In these bands the red colour is absent.

F. *Saurian or Batrachian Band.*—Mr. Johnston-Lavis discovered his *Labyrinthodon Lavisi* by a fall of cliff at F in High Peak Hill in August 1875. The horizon of this stratum ought to strike the beach somewhere under Wind Gate ; but it is hard to say exactly, as the cliff is concealed by bushes and landslips.

The Rev. S. H. Cook in 1876 discovered a small piece of the same fossil bone at G at the fault where the saurian band comes up. He left it with me, and I afterwards forwarded it to Mr. Johnston-Lavis.

The Movements of Underground Waters of North-west Yorkshire.—Sixth and Final Report of the Committee, consisting of Professor W. W. WATTS (*Chairman*), Mr. A. R. DWERRYHOUSE (*Secretary*), Professor A. SMITHELLS, Rev. E. JONES, Mr. WALTER MORRISON, Mr. GEORGE BRAY, Rev. W. LOWER CARTER, Mr. T. FAIRLEY, Professor P. F. KENDALL, *and* Dr. J. E. MARR.

THE boreholes in progress at Turn Dub at the time of the presentation of the last report have now been completed, with the result that the existence of boulder-clay below the bed of the River Ribble at that point was conclusively proved.

In all seven boreholes were put down, but owing to the extremely stony nature of the ground only one of these reached the bed-rock.

This was on the right bank and some 20 feet from the river, and the limestone was reached at a depth of 8 feet below the level of the river-bed.

A full account of the work of the Committee has been published in the 'Proceedings of the Yorkshire Geological and Polytechnic Society,' Vol. XV., Part II., pp. 248–292.

The work of the Committee is now completed, and the grant has been spent, with the exception of a small balance, which has been returned to the Treasurer.

[1] Mr. A. C. Seward has examined the drawing of the plant, and states that the plant may belong to *Schizoneura*. Mr. Hutchinson described and figured his specimen in the *Transactions of the Devonshire Association*, vol. xi. p. 383, in 1879.—J. LOMAS.

Life-zones in the British Carboniferous Rocks.—Interim Report of the Committee, consisting of Mr. J. E. MARR (*Chairman*), Dr. WHEELTON HIND (*Secretary*), Dr. F. A. BATHER, Mr. G. C. CRICK, Dr. A. H. FOORD, Mr. H. FOX, Professor E. J. GARWOOD, Dr. G. J. HINDE, Professor P. F. KENDALL, Mr. R. KIDSTON, Mr. G. W. LAMPLUGH, Professor G. A. LEBOUR, Mr. B. N. PEACH, Mr. A. STRAHAN, Dr. A. VAUGHAN, *and* Dr. H. WOODWARD. (*Drawn up by the Secretary.*)

WORK has been carried on by Mr. J. T. Stobbs in the Holywell district of North Wales and in North Staffordshire. Mr. H. Bolton is engaged in investigating the fauna of a marine band lately discovered by him in the lower coal measures of the Bristol coalfield—a most important and interesting discovery. The marine band is being mined and brought to bank at the expense of the Committee, and a detailed paper will be published at an early date.

Owing to the early date at which this report is required, it must of necessity be incomplete. Arrangements have been made on the one hand with Mr. Stobbs and Mr. E. P. Turner, and on the other with Mr. D. Tait, to undertake work which cannot be done except in the summer, and naturally the result of this work cannot be included; and it is also impossible to state whether there remains over any balance of the grant. The Committee wish to continue the work, and ask for the balance of the grant, if any, to be left in their hands, and that a further grant of 10*l.* be made. Money has been expended in having sections of corals cut for examination. The exact recognition of the species and genera of any coral occurring at a definite horizon has been shown by Dr. Vaughan to be of the highest importance.

My own work during the year has been, first, in the Hodder Valley with Mr. Stobbs, the results of which will appear later; second, in the West of Ireland, where I have demonstrated a typical Pendleside fauna succeeding the Carboniferous Limestone. The results have been published in the 'Proceedings of the Royal Irish Academy,' with figures of the majority of fossils found in the equivalents of the Pendleside series and Millstone Grits in County Clare and County Limerick. The main details of the paper are summed up as follows:—

1. The Pendleside series of the Midlands is well represented in County Clare.

2. These beds in County Clare are about 80 feet thick, and they lie conformably on the upper beds of the Carboniferous Limestone, which seems to have the same top all over the county, and in County Limerick.

3. The fossils are identical with those found at Chokier, in Belgium, and in the Pendleside series of England.

4. The fossils which characterise the lowest beds of the Pendleside series—viz. *Posidonomya Becheri* and *Prolecanites compressus*—have not yet been found in County Clare.

5. That the series of grits and flagstones which overlie the Upper Limestone Shales are, as stated by the Geological Survey, the homotaxial equivalents of the Millstone Grits, and are largely marine in origin, several

well-defined marine bands occurring in them, characterised by *Glyphioceras reticulatum*.

Some facts of great interest came out of the investigation. The forms of *Gastrioceras diadema* which occur at Lisdoonvarna are exactly like those which occur in the Chokier beds of Belgium, beds which come on immediately above the Viséan stage of the Carboniferous Limestone. In both localities this species is accompanied by a peculiar variety, characterised by a large open umbilicus and strong, moderately distant transverse ribs. It seems to me that in this form early characters persisted into the adult stage. The presence of the two forms side by side gives the fossil a time value, and leads to the view that the Chokier and Lisdoonvarna deposits were contemporaneous as well as homotaxial.

The thickness of the series in County Clare (80 feet) and at Chokier, or Clavier, in Belgium (probably not much more), compared to the thickness at Pendle Hill, 1,200 to 1,500, indicates the east and west edges of the basin in which the deposit took place.

The Upper Limestone Shales (Pendleside series) of the West of Ireland are succeeded by a series of grits and flags, in which are slate bands containing a marine fauna, the common fossils being *Pterinopecten papyraceus*, *Posidoniella laevis*, *Glyphioceras reticulatum*, and in this band is a Zaphrientoid coral aff *Z. Phillipsi*.

In conjunction with Mr. J. T. Stobbs, we presented a paper to the Geological Society on the Marine Bands of the North Staffordshire Coalfield, which will be shortly published.

These marine bands, of which several have been discovered in the North Staffordshire coalfield, are of great importance as indices of horizon in sinking and other mining operations, and we contend that we are able by these marine bands, and by the presence of certain species of *Carbonicola*, *Anthracomya*, and *Naiadites* to accurately determine the exact horizon of any seam of coal.

In fact, the whole of the Upper Carboniferous rocks, from the base of the Pendleside series to the top of the coal measures, is now fairly accurately zoned in detail by the Mollusca. In addition, the flora is of assistance in determining the main divisions of that series. But the great faunal change took place before the floral. That is, the flora of the Pendleside series is of Lower Carboniferous type, while the Mollusca have an Upper Carboniferous facies. The great difficulty has always been to establish any zones in the Lower Carboniferous, either where this sub-division consists of massive limestone, as in Derbyshire, or where it has assumed the Yoredale phase, as in North Yorkshire and Scotland.

Last year I quoted the scheme of life-zones worked out by Dr. A. Vaughan for the Carboniferous Limestone of the Bristol area. He and Mr. Sibly have since then demonstrated that the same faunal succession is fairly constant throughout the Mendip and South Wales areas. I have had the privilege of going over the ground with Dr. Vaughan, and have examined the Carboniferous Limestone of the Bristol area at the Avon Gorge ; Failand Section, Flax-Bourton, Wickwar, Chipping Sodbury, Wrington, Burrington Coomb (Mendip), and Weston-super-Mare, and I have no doubt that, for that area, the distribution of the corals and Brachiopods is as he states, and that, so far as this district and South Wales are concerned, the Carboniferous Limestone has been accurately zoned. The fact that a definite sequence of corals and Brachiopods exists

in the South Wales and Bristol areas should afford grounds for hope that it would give a clue to life-zones in the Carboniferous Limestone of the Midlands. But there are enormous difficulties, and at present, though I hope that the corals may give some help, there is no doubt that, as I stated last year, Brachiopods which indicate distinct zones, at Bristol seem to appear with strange companions in the Midlands.

The fauna of the Carboniferous Limestone of the Bristol area is comparatively meagre. No Cephalopods, and at most only some half-dozen species of Lamellibranchs and Gasteropods, occur in the Bristol-Mendip area, and the number of species of Brachiopoda is much less than is found in the Midlands. Conditions of life in the two areas must have been totally different.

Dr. Vaughan and I hope to attack the Midland area in the near future, and with a type district as a basis of comparison we hope to work out a faunal succession. But the task will be immense. There is no complete section of the limestones in the Midlands comparable to that which occurs at Burrington Coomb and the Avon Gorge, and it is probable that not a very great thickness of the limestone of Derbyshire is exposed, because I am not acquainted with the fauna of the lower beds of the Bristol succession in the Midlands. To do the work thoroughly it will be necessary to revise the whole of the species of Brachiopoda, and to spend much money and time on sectioning corals ; it will be also necessary to collect very carefully, and for this purpose a renewed grant will be required.

Dr. F. A. Bather sends me the following note : 'I have examined and attempted to identify various specimens submitted to me by Dr. Arthur Vaughan and other workers. From my point of view, the most interesting fact I have to record is the occurrence of the genus *Acrocrinus* in the Bristol area. This genus, which is a very specialised descendant of *Platycrinidæ*, has hitherto been known only in North America, where it is found in the Later Carboniferous. Its discovery by Dr. Vaughan in his *Zaphrentis* zone near Bristol is, therefore, remarkable as regards distribution in both time and space. The specimen, though fragmentary, is unmistakable, and I propose to publish a description of it before very long. Meanwhile, those who wish to know what the genus looks like may be referred to a reconstruction given on page 159 of the Echinoderm volume of Lankester's "Treatise on Zoology."'

When collecting in the Pendle Hill district in 1901, Mr. D. Tait found a peculiar fossil, which he at once recognised as some form of Graptolite ! Next year he obtained at about the same horizon, at Poolvash, Isle of Man, another form of a somewhat similar organism. After some discussion I referred these fossils to *Dictyonema*, and drew up a brief account, which I read before the Geological Society, March 25, 1903, entitled 'Note on some *Dictyonema*-like Organisms from the Pendleside Series of Pendle Hill and Poolvash.' The paper was not published.

Subsequently I placed the fossils in Miss G. Elles's hands, and she writes me : 'I think the specimens from Poolvash and Hook Cliff are *Dendroid Graptolites*, without a doubt. The Poolvash specimen looks like a *Desnograptus*, and the other is a *Callograptus*, I think. The *Desnograptus* is more spread out than in other specimens known to me, and is probably new, but the *Callograptus* has some very near allies in *C. Salteri* and *C. radiatus* of the older rocks. The presence of the

joining bar has generally been regarded as distinctive of the genus *Dictyonema*, but my experience leads me to believe that this is not the case. "Bars" may be present in all the Dendroids, I think, but they are particularly regularly developed in *Dictyonema* itself. The fashion of growth is a far more distinctive and reliable character.'

We may therefore assume the presence of Dendroid Graptolites in carboniferous rocks.

Mr. Kidston has kindly examined all the plants collected for the Committee, and the determinations are his. He has contributed a paper on the Classification of the Upper Part of the Coal Measures of the Midlands to the Geological Society, published in the 'Quarterly Journal' for May 1905. It contains valuable and accurate lists of plants from the various horizons, which form the evidence for the conclusions arrived at in the paper.

A palæontological survey of the Carboniferous rocks of North Wales has been commenced by Mr. Stobbs and myself. Some important details have already been noted, and will be reported later. Meanwhile further work will be done.

To Record and Determine the Exact Significance of Local Terms applied in the British Isles to Topographical and Geological Objects.—Report of the Committee, consisting of Mr. DOUGLAS W. FRESHFIELD (*Chairman*), Mr. W. G. FEARNSIDES (*Secretary*), Lord AVEBURY, Mr. C. T. CLOUGH, Professor E. J. GARWOOD, Mr. E. HEAWOOD, Dr. A. J. HERBERTSON, Colonel D. A. JOHNSTON, Mr. O. T. JONES, Dr. J. S. KELTIE, Mr. G. W. LAMPLUGH, Mr. H. J. MACKINDER, Dr. J. E. MARR, Dr. H. R. MILL, Mr. H. YULE OLDHAM, Dr. B. PEACH, Professor W. W. WATTS, *and* Mr. H. B. WOODWARD. (*Drawn up by the Secretary.*)

THE work of the Committee is unfortunately not yet sufficiently advanced to warrant the publication of a detailed report. A scheme of work has, however, been arranged and a satisfactory system of recording the words devised.

Each word received is entered upon a separate card and filed in accordance with the principles of a card-index Upon the card is recorded the signed definition by some competent authority, and (where possible) particulars of etymology, literal meaning, and usage in common life, as well as details of the geographical distribution of the latter, are added in spaces provided for the purpose.

A subject-ledger is also being prepared, and it is hoped that this may be illustrated by photographs of typical examples of the objects described.

A list of several hundred interesting words has been formed, and, although many of these still require authoritative definition, progress is being made.

The Committee desire to express their thanks to Mr. H. B. Woodward, F.R.S., for a long list of 'Terms applied to Scenery,' which will form a most excellent nucleus for further work.

The Influence of Salt and other Solutions on the Development of the Frog.—Report of the Committee, consisting of Professor W. F. R. WELDON (*Chairman*), Mr. J. W. JENKINSON (*Secretary*), *and* Professor S. J. HICKSON. (*Drawn up by the Secretary.*)

IN the report presented to Section D at the Cambridge meeting in 1904 an account was given of the development of the frog's egg in a number of isotonic solutions of various substances. The substances employed were :—

1. The chlorides of potassium, lithium, ammonium, calcium, magnesium, barium, strontium, and sodium.
2. The bromides of the same bases.
3. The iodides of sodium, potassium, lithium, and ammonium.
4. The nitrates of sodium, lithium, ammonium, potassium, magnesium, strontium, and calcium.
5. The sulphates of sodium, lithium, ammonium, and magnesium.
6. Cane sugar and dextrose.
7. Urea.

These substances were employed in solutions isotonic with a solution of sodium chloride—0·625 per cent.—which was known to produce a certain distortion of development, and the object of the experiment was to ascertain whether the effects observed were due to the increased osmotic pressure of the medium or to some other cause.

Since the publication of the last report the microscopical investigation—which was not at the time quite completed—has been brought to a conclusion, the experiments have been repeated and confirmed—in one or two points corrected—and some new experiments undertaken to throw light, if possible, on the same problem. The present report embodies :—

I. A corrected *résumé* of the growth of the egg in the isotonic solutions referred to, to which potassium sulphate has been added.
II. An account of the results of the fresh experiments.

I. *Solutions Isotonic with* 0·625 *per cent.* NaCl.

In the last report these solutions were divided into four classes, according to the effect produced.

A. The egg dies in an early stage ; segmentation or gastrulation. This occurs with NH_4Cl, $SrCl_2$, $BaCl_2$, $CaCl_2$, NH_4Br, $SrBr_2$, $BaBr_2$, $CaBr_2$, $MgBr_2$, LiI, NH_4I, KI, NH_4NO_3, $Ca(NO_3)_2$, $Sr(NO_3)_2$.

The liquefaction of yolk-granules, ascribed before to all these solutions, has been found not to occur in NH_4I, LiI, KI, NH_4Br, NH_4NO_3, or $Ca(NO_3)_2$.

B. The egg loses its power of elongating, and remains nearly spherical ; differentiation of the germ-layers and of the organs of the embryo proceeds nevertheless. This effect was stated to be produced by KCl and $LiCl$, $NaBr$, KBr and $LiBr$, NaI, Li_2SO_4 and $(NH_4)_2SO_4$, $LiNO_3$ and KNO_3.

1. It has been found that in sodium bromide development goes further

than in the others; this substance must accordingly be removed from this class and placed in the next.

2. Degeneration and death occur much earlier in lithium bromide, potassium bromide, sodium iodide and ammonium sulphate than in the remainder. In these four salts the medullary groove never closes, even if it is formed; the auditory vesicles, infundibulum, optic vesicles, cœlom, heart and suckers are never developed. It would be better, therefore, to put this group by itself as a second class.

(3) To the remainder potassium sulphate must now be added.

In all these salts a considerable degree of differentiation takes place, but the embryo is unable to elongate. The blastopore is often closed, as also are the medullary folds. Optic vesicles, auditory vesicles and infundibulum are formed, often a small peritoneal cavity, and sometimes (lithium nitrate) a pericardium and heart, or a trace of the pronephros (potassium chloride). These embryos always die without hatching out; the innermost layer of the jelly does not expand and leave the embryo room to elongate, as happens in normal development at about the time when the medullary folds are formed.

C. In the third class of the last report were placed those solutions—sodium chloride and nitrate, magnesium chloride, nitrate and sulphate, cane sugar and dextrose—in which, though this elongation takes place, development is nevertheless distorted and death eventually ensues.

As noted above, it has now been found necessary to associate the bromide with the nitrate and the chloride of sodium in this class; further, it is advisable to make a distinction between (1) these three sodium salts, (2) the three magnesium salts, and (3) the two sugars.

(1) In the bromide, chloride, and nitrate of sodium the blastopore as a rule does not close and the medullary folds remain open, usually only in the region of the brain, though sometimes throughout. The variability exhibited by eggs of the same batch in the same solution in this respect is very remarkable.

A tail is formed—sometimes single, sometimes double; and gills (external) and gill-slits, blood-vessels, pronephros, and glomus are present.

The embryo may even hatch out and attach itself to the jelly by its suckers, but it soon falls to the bottom and dies.

(2) The three salts of magnesium are more favourable to development. The blastopore closes, and a fairly long tail, provided with a fin, grows out; but the brain remains open and undergoes the same grey degeneration, as described in the previous report, found in the monsters produced in the solutions already mentioned.

Such internal organs as the eyes, the heart and pericardium, the blood-vessels, the pronephros, and duct are better developed than before.

(3) The solutions of dextrose and cane sugar stand apart from the rest.

The blastopore closes, though slowly, and the yolk-plug is withdrawn in both.

In dextrose the medullary folds nearly close without undergoing any marked degeneration, and the embryo differs mainly from a normal one in the great retardation of development; the optic vesicle, for example, appears five days later in the dextrose embryo than in the controls.

In cane sugar, on the other hand, the medullary folds remain widely open and suffer grey degeneration; and the embryo dies before the heart, the blood-vessels, the optic cup and lens, the gill-slits and the pronephros are formed.

It may be mentioned here that, in view of the possible objection that this effect might be due to bacterial toxines, this experiment was repeated under special conditions. The embryos were kept in a constant stream of sugar solution, which flowed through the apparatus at the rate of two litres per diem.

D. The fourth class comprises urea and sodium sulphate; in these development is nearly (urea) or quite (sodium sulphate) normal in form and rate.

Little remains to be added to the account given last year, except that the microscopical investigation has fully borne out the statement made of the external characters of these embryos.

To sum up, these isotonic solutions may be grouped according to their effects as follows:—

1. Solutions which kill the egg in an early stage (segmentation or gastrulation).

2. Solutions which kill the embryo at a rather later stage, when the medullary plate is being formed, without permitting any very great degree of differentiation.

3. Solutions which, though they allow differentiation to proceed for some way, do distort development:—

α. The embryo remains spherical.

β. The embryo elongates.

Differentiation may go as far in α as in β.

4. Dextrose must be placed in a class by itself; it seems to affect the rate only, the form of development hardly at all.

5. Solutions in which development is nearly or quite normal.

It is clear that it would be extremely difficult to assign the whole of the effect produced in each case to the increased osmotic pressure of the medium, and to that alone; to do this it would be necessary to assume that the effect was inversely proportional to the permeability of the embryo to the substance employed. There is, of course, no direct evidence for this whatever.

Animal tissues are, indeed, supposed to be more or less impermeable to magnesium salts, which produce a less, and permeable to sodium chloride, which produces a greater, effect.

The toxicity of the reagents must far more probably be set down to some other physical or chemical property they possess, though what this is it is impossible to say exactly at present. This is clearly shown by an experiment which has been made during the present year.

II.

Ammonium bromide is one of the most poisonous of the substances tried; in a solution whose concentration (1·04 per cent.) is isotonic with that of a 0·625 per cent. sodium chloride solution the egg dies during segmentation.

Weaker solutions have now been tried, and this is the result:—

0·26 per cent.: a segmentation cavity is formed; then a dorsal lip of the blastopore and a very short archenteron; death follows.

0·13 per cent.: the result is the same.

0·065 per cent.: the result is the same.

This is clearly not due to the increase of osmotic pressure; the same must be said of all the substances of Class A.

As a matter of fact, there is not any evidence that the egg does normally absorb water to any extent while the closure of the blastopore is taking place; it is only after the blastopore has become reduced to a small circle, and when the medullary folds are being formed, that the innermost membrane of the jelly begins to expand and the embryo to elongate. Prior to this, therefore, it does not seem likely that the egg would be sensitive to a loss of water. Afterwards, however, we do know that the embryo absorbs water very rapidly, for Davenport has shown that during the first fortnight after hatching the percentage of water rises from 50 to nearly 90. By observing the effect produced on *tadpoles* by these solutions it seemed, therefore, possible to ascertain the permeability of the tissues to the various substances, and so obtain a sounder basis for judging of the effects of these solutions upon the earlier stages.

The tadpoles were accordingly placed, shortly after hatching, in solutions—of the same concentrations as those already employed—of cane sugar, sodium chloride, urea, and sodium sulphate.

In the first two the tail becomes curled up over the back; the mouth becomes, as in the controls, transversely elongated, the suckers oval, the operculum begins to grow back over the three external gills; then the larvæ die.

In urea the tail remains straight; in other respects the tadpoles resemble the last; these also die in about five or six days after immersion in the solution.

Microscopical examination shows that differentiation has been going on at nearly the same rate as in the controls; the cavities of the gut, brain, pronephros and ducts, lungs, cœlom, blood-vessels, are all, however, much reduced; they are most reduced—in fact, almost obliterated—in cane sugar, less so in sodium chloride, least in urea; in sodium sulphate they do not appear to be reduced at all.

This result seems to show pretty clearly that the embryonic tissues are less permeable to cane sugar than to sodium chloride, less to sodium chloride than to urea, and less—a very little less—to urea than to sodium sulphate; the two latter, however, seem to be nearly harmless, and, though free to permeate the body of the larva, do not produce, at any rate at first, any marked deleterious effect.

That these solutions do penetrate is shown, possibly, in another way. When a normal tadpole is preserved, as these were, in picric acid, the chordal sheath becomes crumpled, owing to the extraction of water from the notochord; the sheath of the cane sugar tadpoles is also crumpled, but not in sodium chloride, sodium sulphate, or urea.

It may be noticed that in cane sugar and sodium chloride the diameter of the notochord is greater than the normal; apparently this organ continues to absorb water from the tissues and to grow in length (as well as in breadth); the dorsal caudal is wider than the ventral caudal fin; the dorsal curvature of the tail in these two solutions may thus possibly be accounted for.

Assuming that the permeability of the embryo to the different substances is the same in earlier stages as in the tadpole, these results may be applied to the interpretation of those obtained before as follows:—

1. The embryo is probably impermeable to dextrose; the effects pro-

duced by this solution are then due entirely to its capacity of withdrawing water that is needful for development.

2. Other solutions—those of the first class—are toxic in virtue of some other property, though what this is is unknown.

3. The same may be said of the solutions of the second class.

4. In the case of the chloride, nitrate and bromide of sodium, the chloride, nitrate and sulphate of magnesium, the increased osmotic pressure may play some part, though it certainly is not responsible for the whole effect. Cane sugar may be best associated with these.

5. The behaviour of those eggs which remain spherical though differentiation continues is probably not to be put down to the increased osmotic pressure alone; these embryos are quite unlike the dextrose embryo. It seems more likely that the substances enter the ovum, and there interfere with processes (? proteolytic fermentations) that would normally result in the production of substances with a higher osmotic pressure than, and capable of absorbing water from, the medium. That potassium chloride, for example, does penetrate the tissues is proved by the liquefaction of yolk-granules which occurs in this solution.

Finally, there remains to be described the effect of more concentrated solutions of substances—urea and sodium sulphate—which are known to penetrate the embryonic tissues, but in the strengths employed before were harmless.

Sodium Sulphate.—The solutions employed were: (1) 1·16 per cent. (this is the original concentration); (2) 1·325 per cent.; (3) 1·54 per cent.; (4) 1·85 per cent.; (5) 2·32 per cent.; (6) 2·5 per cent.; (7) 3 per cent.; (8) 3·5 per cent.; (9) 4 per cent.

(1) Development is normal.

(2) The brain and blastopore may both remain open; the open brain degenerates and becomes grey. Internally there is considerable differentiation; nerve-fibres are developed in the spinal cord, the eye—retina, choroid fissure, lens—is normal, the heart is bent, there are three pronephric funnels, and the peritoneal cavity is large. The stomodæum is, however, still closed at the time when the larva dies.

(3) Much as the last, but the optic cup is not quite normal and the lens is solid.

(4) The tail is very short and the fin badly developed. Internally the peritoneal cavity is not developed, and the gut lumen is very narrow.

(5) The tail is shorter still, and the medullary groove is open and grey throughout. This embryo resembles a typical sodium chloride monster. The heart is solid, and there is only one pronephric funnel.

(6) Externally this resembles the last. Internally the pericardium is smaller, the gill-slits are absent, and there is only a pronephric ridge—no tubules. The notochord is still vacuolated.

(7) In this solution degeneration sets in at a much earlier stage. The yolk-plug is very large; the medullary folds are formed and become grey; below what appears to be the dorsal lip of the blastopore is a grey zone between the lip and the white yolk-plug. Sections, however, discover the interesting fact that the lower margin of this grey zone is in reality the blastoporic lip, and is separated from the yolk by a slight indentation. The apparent blastoporic lip is the rim of an aperture leading into an archenteric cavity, as it must be called, since notochord and

mesoderm are differentiated in its roof, but situated wholly *within* the animal hemisphere.

(8) These embryos resemble the last, but neither medullary groove, notochord, nor mesoderm is formed.

(9) There is, perhaps, a slight blastoporic invagination, but the animal hemisphere is so exceedingly rough and corrugated that this is hard to make out.

Part of the roof of the segmentation cavity is thickened and infolded; this seems to represent a medullary plate.

Urea.—The original concentration of urea employed was 1·14 per cent.

The eggs were placed in the following more concentrated solutions: (1) 1·17 per cent.; (2) 1·33 per cent.; (3) 1·56 per cent.; (4) 1·87 per cent.; (5) 2·34 per cent.

α. 2·34 per cent.—The yolk is nucleated, but unsegmented; the animal hemisphere is incompletely segmented; it consists of a mass of small uni- or multi-nucleate masses covered by a layer of flat cells. The nuclei are either very large, pale and reticular, or small and homogeneous. Very often the animal hemisphere is thrown into round, projecting, multinucleate masses, which recall the 'framboisia' of Roux. The egg does not advance beyond this condition.

β. 1·87 per cent.—In its effects this solution closely resembles the last; there are, however, more nuclei in the yolk.

γ. 1·56 per cent.—The contrast between this and the last is rather remarkable. The medullary folds are *wholly closed*; there is, however, a small persistent yolk-plug; the tail is short and provided with a fin; there is a nostril, and the external gills and gill-slits are formed. A bent heart, fairly large pericardium, blood-vessels, and auditory vesicle are formed; the pronephros has only one funnel, and the duct is not open to the cloaca; the retina is well developed, with the choroid fissure, but there is no lens.

Quite the most remarkable feature of these embryos is, however, the doubling or tripling of the notochord.

In addition to the usual vacuolated chord between the roof of the gut and the spinal cord, two other notochords, as they must be termed, are found, sometimes three others: (1) The cells which form the roof of the gut take on the characteristic vacuolation of notochordal tissue; the mass of cells so formed is irregular, but certain parts of it become rounded off and assume a cylindrical shape like the notochord proper. This 'enteric' notochord, as I will call it, is fused here and there with the notochord proper, and is found usually about the region of the heart only.

(2) A certain lateral or latero-ventral portion of the wall of the medullary tube behaves in precisely the same way, the vacuolated cells actually lying next the lumen. This 'neural notochord' may, but does not necessarily, fuse with the notochord proper; it, too, does not extend the whole length of the body.

(3) Lateral 'mesodermal notochords' may be formed in the same way.

This occurrence of a specific kind of histological differentiation in an abnormal situation is a point of considerable interest, showing, as it does, that the prospective potentiality of gut roof, protovertebræ and medullary tube is not yet fixed. It also suggests the possibility that the formation of the normal notochord may be due to the accumulation—in the mid-dorsal line—of the excretory products of the extremely active metabolism

that is there going on as a result of the bilateral closure of the blastopore.

δ. 1·33 per cent.—The tail is rather longer and the fin broader than before. The yolk-plug is wholly withdrawn. A lens is formed and nerve-fibres are differentiated.

Three notochords—ordinary, 'neural' and 'enteric'—are found, as in the last.

ε. 1·17 per cent.—In this solution development is nearly normal. There are three pronephric funnels and the peritoneal cavity is large. An 'enteric' but not a 'neural' notochord is found.

It may be pointed out that the distorted developments produced by these concentrated solutions of sodium sulphate and urea are not like the effects of, for example, dextrose.

The reasons for believing that the tissues are permeable to these two substances have been given, and it does not seem likely that the increased osmotic pressure plays, at any rate, an important part in the process.

At the same time, it must be confessed that these experiments do not, of themselves, conclusively prove that the embryo absorbs no water during the closure of the blastopore. It would be advisable to institute a series of 'desiccation' experiments, and also to grow the embryo in stronger solutions of dextrose. This it is hoped will be done next season.

Apart, however, from this particular problem, the experiments above described have brought out several points which throw an interesting side-light on certain of the processes of normal development: for example, the reduction of the lumen and increase in thickness of the walls of the medullary tube in those cases in which the embryo remains spherical recalls the 'solid' medullary groove of Petromyzon, Teleostei, and certain other fishes; again, the way in which the medullary groove closes in certain cases resembles the mode of its closure in Amphioxus; the formation of the notochord in many of these solutions from the whole thickness of the archenteric roof is just what occurs normally in some Anura, the Urodela, and Petromyzon. These instances will suffice to show that experiments of this kind may be fruitful in results which can be applied to the causal explanation of developmental events. This and kindred work will, it is hoped, be continued, and for all these reasons the Committee ask that they may be reappointed, with a renewal of the grant.

Occupation of a Table at the Zoological Station at Naples.—Report of the Committee, consisting of Professor S. J. Hickson (*Chairman*), Rev. T. R. R. Stebbing (*Secretary*), Professor E. Ray Lankester, Professor W. F. R. Weldon, Professor G. B. Howes, Mr. A. Sedgwick, Professor W. C. McIntosh, *and* Mr. G. P. Bidder.

The table has been occupied during the greater part of the year by Mr. Geoffrey Smith, B.A., who has been engaged in a research upon the Rhizocephala.

Dr. Edith M. Pratt visited the station in April and, by the kindness of Dr. Dohrn, was allowed to occupy a table during her stay there, the Association's table being then in the occupation of Mr. Smith.

The Committee have to lament the decease of their esteemed colleague

Professor Howes, and, with the necessary omission of his name, they desire to be reappointed and ask for the requisite grant of £100.

The reports of Mr. Smith and Miss Pratt are appended.

Report of Mr. Geoffrey Smith, B.A.

When I was appointed to the table at the beginning of this year I was engaged in writing a monograph on the Rhizocephala for the station. During my occupation of the table I have continued that work, and it is now finished and ready for publication, with the exception of one chapter, which I hope to finish during the summer.

The monograph will contain the following chapters :—

I. General Introduction, Morphology, and Review of Literature.

II. Reproduction and Sexual Organisation. Maturation and Parthenogenesis of Ovum in Sacculina and Peltogaster. History of complemental males.

III. Embryonic development and larval history of Sacculina and Peltogaster.

IV. Fixation of larva on host (*not yet finished*) and inoculation.

V. Endoparasitic development of Sacculina and Peltogaster, with accounts of earliest stages not described by Delage. Organogeny.

VI. The effect of the parasite on its host : parasitic castration and the production of perfect hermaphrodites through the influence of the parasite. An analysis of sex afforded by the facts of parasitic castration.

VII. The life history of *Danalia curvata*, an Isopodan parasite of Sacculina. General discussion on meaning of hermaphroditism of fixed animals.

VIII. Systematic guide to the genera and species of Rhizocephala.

Besides this monograph, which will be published during the coming winter, I have finished, whilst in the occupation of the table, a paper on High and Low Dimorphism, which was begun during the previous year, and will be published in the Station 'Mittheilungen' in the winter. Also a short note on a new species of gregarine, which causes the parasitic castration of a species of spider-crab. This is the first clear instance of a gregarine as the cause of parasitic castration.

Report of Miss Edith M. Pratt, D.Sc.

By the kindness of Dr. Dohrn I was allowed to occupy a table at the Zoological Station at Naples from April 5 to April 26, 1905. During that time I made an experimental investigation of the excretory apparatus of Pennatulida and the phenomena of the expansion and contraction of their rachis.

I also made some feeding experiments on several other Cœlenterata, and have confirmed my previous observations on the distribution of nutriment in *Alcyonium digitatum*.[1] The examination of microscopic preparations of the preserved material used in my experiments is being carried out in the zoological laboratory in the University of Manchester, and the results will be prepared for publication shortly.

I must express my gratitude to the Committee for recommending me to the privilege of occupying a table.

[1] *Brit. Assoc. Rep.*, Sect. D., 1903.

Investigations at the Marine Biological Laboratory, Plymouth.—Report of the Committee, consisting of Mr. W. GARSTANG (*Chairman and Secretary*), Professor E. RAY LANKESTER, Mr. A. SEDGWICK, Professor SYDNEY H. VINES, *and* Professor W. F. R. WELDON. (*Drawn up by the Secretary.*)

THE British Association's table at the Plymouth Laboratory, available for one month during 1904–05, was allotted, after application, to Professor E. W. MacBride, F.R.S., to enable him to carry out further investigations on the development of *Ophiothrix fragilis*.

Professor MacBride's report is appended.

Report on the Work done during the Occupation of the British Association Table at Plymouth, June 1905. *By* Professor E. W. MACBRIDE.

The subject selected for investigation was the development of the common British species of Ophiurid, *Ophiothrix fragilis*. It was hoped that sufficient material would have been obtained to make a thorough and exhaustive investigation of the development of the organs in an Ophiurid pluteus, and their metamorphosis into those of the adult. Though this result was not attained on this occasion, the development of the larva from the egg up to an age of sixteen days was traced step by step. At this period the larva has attained its full development, and the first trace of the metamorphosis has appeared.

In 1898, when occupying the Cambridge University table at Plymouth, I was more fortunate, as I then succeeded in getting two or three larvæ to complete their development; a process which occupied twenty-three days. In 1899, when occupying the table of the British Association, I was fortunate enough to obtain a large quantity of Plankton, with numerous specimens of the pluteus of *Ophiothrix* in various stages of metamorphosis, and with the aid of the material obtained this year I hope eventually to be able to give a complete account of the development of *Ophiothrix fragilis* similar to the account I have already given of the development of *Echinus esculentus*.

The cause of my failure to rear the larvæ completely through their metamorphosis this year was the scarcity of the proper Phytoplankton. In 1898 this was particularly abundant, and the free-swimming form *Coscinodiscus* seems to have been the one which caused the experiment to succeed. This year, although every device was tried—a limited number of the larvæ (which are much smaller than those of *Echinus esculentus*) being placed in a 10-gallon bell-jar fitted with a plunger—after a certain period the larvæ ceased to develop; they then sank to the bottom, where they continued to live for a considerable time, slowly absorbing the long arms (*i.e.*, processes of the ciliated band) till in extreme cases they assumed the forms of little triangles, all the arms having disappeared. Control experiments made in 2-gallon jars, which were immersed in the water of the tanks, showed that temperature had no influence in the result; and the perfect health of the larvæ as long as any food could be discerned in their stomachs showed that the other conditions were all right.

In this connection it must be noted that there is apparently a

connection between the appearance of the proper food in the water and the ripening of the adults. In 1898 there was no difficulty in finding ripe males and females ; in fact it was their evident abundance which induced me to undertake the experiment of rearing the larvæ on that occasion, as the main object of my investigation then was the development of *Echinus esculentus*. But this year, although hundreds of specimens were examined, only two ripe females were found, the second of which, however, spawned naturally and provided me with abundance of fertilised eggs. These eggs are small and opaque, yellowish-red by reflected light. They are about 0·1 mm. in diameter. When sections of the segmentation stages are made, it is seen that segmentation leads to the formation of a solid morula—not to the formation of a blastosphere as in other Echinoderms. At fifteen hours the eggs have become free-swimming larvæ, which consist of a superficial sheet of tall ectoderm cells and an interior mass of rounded cells. A little later an invagination appears at one end, pushing these cells to one side, and in this way the gastrula stage is attained. The larva now assumes the shape of a V by the appearance of lateral outgrowths, the dorso-lateral arms so characteristically predominant throughout the later history of the larva. It is then seen that the cells which constitute the interior mass of the earliest larva are the mesenchyme cells destined to form the supporting rods for these arms, and the difference between the development of *Ophiothrix* and that of other Echinodermata is simply due to the precocious appearance of this mesenchyme.

The cœlom is formed, as in Asterids, as a vesicle from the apex of the gut and becomes immediately divided into right and left halves, and the left sends out a dorsal outgrowth which forms the primary pore-canal and forms the first madreporic pore. Each portion of the cœlom next divides into anterior and posterior halves, and the short præ-oral and post-oral ciliated 'arms' of the larva are formed. Then when the age, nine to ten days, is attained the posterior dorsal arms make their appearance, completing the equipment of the larva. It is worthy of note that the entire larval skeleton consists of two spicules of carbonate of lime—a right and a left one. The main branches of the spicules support the main dorso-lateral arms ; as new arms are formed branches of the spicule extend into them.

At about eleven days the anterior cœlom on each side shows a posterior swelling, which is at first a solid mass of cells, but soon becomes hollow. That on the left side assumes the characteristic five-lobed appearance which distinguishes it as the *hydrocœle* or rudiment of the water-vascular system. That on the right side is at first exactly similar to that on the left, and appears at the same time. It becomes hollow, but never takes on the five-lobed form ; and later it seems to become again a solid mass of cells. There is no doubt at all that it is a rudimentary fellow of the hydrocœle, and its appearance points to the conclusion that this organ was originally double. I have described a right hydrocœle in the case of *Echinus esculentus* and *Asterina gibbosa* ; but in neither case was its nature so beautifully evident as in the case of *Ophiothrix fragilis*. Bury [1] maintained that the hydrocœle in Ophiuridea was formed from the posterior division of the cœlom. This is a mistake, easily explicable if earlier stages are missed out, for the posterior cœlom

[1] 'The Metamorphosis of Echinoderms,' *Q.J.M.S.*, 1895.

grows forward and becomes closely apposed to the hydrocœle, leading easily to the belief that the two are organically connected.

So far only have my investigations extended. I trust this winter to be able thoroughly to investigate the metamorphosis. I may add one interesting observation which I was able to make on the habits of the adult *Ophiothrix fragilis*. The characteristic radial plates in the dorsal skeleton of an Ophiurid have hitherto reached an explanation. When a number of specimens just brought in were placed in a limited quantity of water they were seen to alternately raise and depress these ossicles, with the result that the dorsal surface was alternately raised into a conical form and depressed. On dissection it was found that the radial plates articulated with one of the vertebræ in each arm, and on each side of the articulation there were muscles by whose aid the movements were produced. The object of the movement is no doubt respiratory. Since both genital bursæ and stomach are attached by bands to the dorsal surface of the test, they must necessarily be expanded by the upward movement, and must collapse with the downward, causing an alternate inflow and expulsion of water. The ordinary respiration of an Ophiurid results from the action of the cilia lining the genital bursa; so that these movements may be compared to the forced respiratory movements of the ribs in man as opposed to the action of the diaphragm.

In conclusion I should like to express my obligations to Dr. Allen and his able assistant, Mr. Smith, for their untiring efforts in aid of my work.

Index Generum et Specierum Animalium.—*Report of the Committee, consisting of* Dr. HENRY WOODWARD (*Chairman*), Dr. F. A. BATHER (*Secretary*), Dr. P. L. SCLATER, REV. T. R. R. STEBBING, Dr. W. E. HOYLE, *and the* Hon. WALTER ROTHSCHILD.

SATISFACTORY progress has been made by Mr. Davies Sherborn in the recording of literature from 1801 onwards. Among other works now indexed up to 1850 may be mentioned the 'Annals and Magazine of Natural History,' the 'Academia Cæsarea,' and the 'Neues Jahrbuch für Mineralogie.' Various tracts dealing with the collation of difficult books have been issued, and a reprint of the descriptions of new species of birds drawn up by Pallas for 'Vroeg's Catalogue,' 1764, has been published by the Smithsonian Institution, under Mr. Sherborn's care, from the unique copy in the Linnean Society's Library. The search for rare books still continues, and any such acquisitions are made available for public use by transference to one or other of the accessible libraries. Special thanks are due to the Italian Government, the University of Padua, and Professor Dante Pantanelli, for enabling the Committee to examine the 'Tavola alfabetica delle conchiglie adriatiche' of Stefano Andrea Renier (1804). Help of this nature, as well as valuable criticism, is continually forthcoming from home and abroad, and the general interest taken in the published volume (1758–1800) is highly gratifying to Mr. Sherborn and satisfactory to this Committee, which, in this connection, desire to thank especially Mr. L. B. Prout and Mr. C. W. Richmond.

The Committee desire to be reappointed, with the addition of Lord Walsingham, and trust that the grant will be restored to the previous amount—namely, 100*l*.

The Zoology of the Sandwich Islands.—Fifteenth Report of the Committee, consisting of Professor NEWTON *(Chairman)*, Mr. DAVID SHARP *(Secretary)*, Dr. W. T. BLANFORD, Professor S. J. HICKSON, Dr. P. L. SCLATER, Dr. F. DU CANE GODMAN, *and* Mr. EDGAR A. SMITH.

THIS Committee was appointed in 1890, and has been since annually reappointed.

Since the last report parts of the collections worked out have been delivered to the British Museum (Natural History) and to the Bernice P. Bishop Museum at Honolulu. The Secretary has done a little towards the working out of the remaining Coleoptera, but there is still a great deal to do to complete this Order of Insects.

The Committee therefore ask for reappointment, with a continuance of their powers, but do not require a grant of money.

Madreporaria of the Bermuda Islands.—Report of the Committee, consisting of Professor S. J. HICKSON *(Chairman)*, Dr. W. E. HOYLE *(Secretary)*, Dr. F. F. BLACKMAN, Mr. J. S. GARDINER, Professor W. A. HERDMAN, Mr. A. C. SEWARD, Professor C. S. SHERRINGTON, *and* Mr. A. G. TANSLEY, *appointed to conduct an investigation into the Madreporaria of the Bermuda Islands.*

THE Committee beg leave to report that no opportunity has presented itself of sending a naturalist to the Bermuda Islands to carryout the investigation. The Committee has been in readiness to co-operate with the authorities of the marine laboratory established by the United States, but they have not found any means of taking combined action. As they are of opinion that they are not likely to be able to render any useful service in the near future, the Committee do not ask to be reappointed.

Zoology Organisation.—Report of the Committee, consisting of Professors E. RAY LANKESTER *(Chairman)*, S. J. HICKSON *(Secretary)*, T. W. BRIDGE, J. COSSAR EWART, M. HARTOG, W. A. HERDMAN, *and* J. GRAHAM KERR, Mr. O. H. LATTER, Professor E. A. MINCHIN, Dr. P. C. MITCHELL, Professor C. LLOYD MORGAN, Professor E. B. POULTON, Mr. A. SEDGWICK, Mr. A. E. SHIPLEY, *and* Rev. T. R. R. STEBBING.

THE Committee report that a Register of Zoologists has been established and that fifty-seven zoologists have accepted the invitation of the Committee to place their names upon the Register.

The Committee have obtained by correspondence the opinion of a large number of the zoologists of the country upon the question of the importance of the grant applied for by the Committee of Section D to enable a Committee to send a competent investigator to the Zoological Station in

Naples. Other matters affecting the interests of zoologists in the country have engaged the attention of the Committee during the year.

A meeting of the Committee was held in London on May 11.

A meeting of zoologists summoned by the Committee to consider the question of the teaching of natural history in schools was held in the Zoological Gardens, London, on the same date.

The Secretary has received in subscriptions and donations 21*l.* 2*s.* 7*d.*, and spent in postage and printing 4*l.*

The Committee ask to be reappointed.

Colour Physiology of the Higher Crustacea.—Interim Report of the Committee, consisting of Professor S. J. Hickson (*Chairman*), Dr. F. W. Gamble (*Secretary*), Dr. W. E. Hoyle, *and* Mr. F. W. Keeble, *appointed to enable Dr. F. W. Gamble and Mr. Keeble to conduct Researches in the Colour Physiology of the Higher Crustacea.*

Last summer, in Mr. Keeble's laboratory at Tiegastel, Brittany, a further spell of work on the colour physiology of the higher crustacea was carried out by Messrs. Gamble and Keeble. Its results have recently appeared in the 'Philosophical Transactions,' and form the necessary preliminary to that research on the relation between respiratory phenomena and colour change for the furtherance of which this grant was made last summer. That research can only be carried out in the summer vacation, and Messrs. Keeble and Gamble are just about to start experimental work, and have not yet spent the grant. Accordingly, in presenting this interim Report, the Committee ask to be reappointed and for the grant to be renewed.

On the Accuracy and Comparability of British and Foreign Statistics of International Trade.—Report of the Committee, consisting of Dr. E. Cannan (*Chairman*), Mr. W. G. S. Adams (*Secretary*), Mr. A. L. Bowley, Professor S. J. Chapman, *and* Sir R. Giffen.

The Committee have made inquiries during the past year with regard to the statistics of imports and exports published by the Governments of British Colonies and other States forming part of the British Empire. Owing to the shorter interval available for such inquiry, and also to the delays consequent in obtaining information from lands widely distant, it has not been found possible to do more than carry this investigation through the preliminary stages; but it has seemed desirable that the facts already collected, and certain general considerations arising out of them, should be presented as an interim report. The accumulation of information on a complex and highly detailed question such as the accuracy and comparability of international statistics may be persisted in profitably for a succession of years, and the patient and comprehensive study of the subject should materially assist in forwarding reforms of practical value. The inquiry has been continued largely on the lines adopted in the previous report, and is supplementary to it.

The subject-matter is presented under the following heads :—

A. Definition of International Trade.
B. Estimation of Values of Imports and Exports.
C. Determination of the Country of Origin and of Destination.
D. Classification of Articles of Import and Export.
E. Recent Changes affecting Import and Export Statistics.
F. Comparability and Accuracy.
G. Suggestions as to Reform.

A. *Definition of International Trade.*

Owing to the more explicit statements which now preface colonial reports and tables, errors are less likely to be made now than formerly as to what is included in the returns of imports and exports.

(1) It is usual in the colonial returns of imports and exports to include all articles which are landed, even though only for transit purposes, but to exclude such articles as are transhipped but not landed. It is deserving of note, however, that in the case of Canada, as stated in a memorandum received by the Committee from the Minister of Customs, Ottawa, the transit trade is not included in either the import or export statements, and, in fact, is not compiled for publication, except in so far as the port of Montreal is concerned. This trade for the port of Montreal during the fiscal year ended June 30, 1903, was $11,689,912. In it are included articles intended for other countries which pass through Canada in the course of their transportation, but which have not been purchased or sold in Canada and are not intended for use in Canada. In the case of Trinidad, on the other hand, where, comparatively speaking, there is a considerable transhipment trade from the Port of Spain to the Orinoco, such trade is included in the exports of Trinidad, but the fact is clearly stated in the Customs returns of the colony.

(2) The practice as to the inclusion or exclusion of bullion and specie varies in the statistical returns of the several colonies, but explicit statements are made on the subject, which should prevent error. In the Australian statistics bullion and specie are not separated, as in the import and export returns of the United Kingdom. It is considered that bullion in the case of Australia is as purely commercial an export as wool, and likewise the common practice of converting bullion into specie for commercial convenience justifies the classification of specie no less than bullion with other articles of merchandise. On the other hand, in the statistics of Cape Colony bullion is included among the articles of merchandise, but specie is treated separately. Similarly, in the Canadian statistics gold is classified with other merchandise, but coin is shown separately. In the Indian statistics, treasure, which includes gold and silver, bullion and specie, is distinguished from merchandise. Owing to the varying practice thus existing, care is necessary in comparing totals. It should be further noted that in some cases coal, as well as bullion and specie, is excluded from the articles of merchandise. Thus in his report the Collector-General of Customs in Jamaica gives the total of imports and exports, excluding coal, bullion, and specie; whereas in the report of the Collector of Customs in Trinidad no such distinction is observed.

(3) It is noteworthy that, before the formation of the Australian Commonwealth, imports and exports into any Australian State from a border State—for example, to Victoria from New South Wales—were

distinguished from over-sea imports and exports. Similarly in the Commonwealth returns a very clear distinction is made between inter-Australian and other trade. In the case of South Africa the difficulties are greater in distinguishing South African inter-State from external imports and exports, though the distinction has been and is made in the returns of the several States.

B. *Estimation of Values of Imports and Exports.*

Imports.—With regard to the estimation of the value of imports, the general practice in the colonies is to require and accept a declaration of value from the importer. As to the reliability of such statements, a distinction must be made between goods which are dutiable and goods which are free. In the case of dutiable goods, it is evident that very considerable care is taken to arrive at the fair value of the goods imported. Thus the Committee are informed that in Cape Colony every means is taken to ascertain the correctness of the declared value either from price-lists published by firms of repute or from price-lists quoted by commission firms, and in addition an importer has to produce, before his goods are delivered, his bill of lading, statement, and invoices, the correctness of which he can be called upon to declare under oath. On the other hand, in the case of free goods, even if the Customs authorities do not apply an equally careful scrutiny as in the case of dutiable goods, there is not the same inducement on the part of the importer to understate valuation; but, in any case, the importance which is now attached to a correct knowledge of imports free as well as dutiable, and the attention given by the Customs authorities to the matter, ensure the comparative reliability of the statements of value as regards free goods. The main feature in the estimation of values of imports—namely, that it is declared and not official—is the same throughout the Colonies, but there are several points of difference in detail which have been brought to the notice of the Committee.

South Africa.—In the South African Customs Union the value of goods imported is taken to be the current value of such goods in the open market at the place of purchase by the importer or his agent, but in such current value are included the cost of packing and packages, and, if it exceeds 5 per cent., the agent's commission. Agent's commission, where it is less than 5 per cent., together with freight and insurance, is not included. On the other hand, with regard to the valuation of imports for statistical as against duty purposes, there appear to be certain differences in the practice of the several South African States. Thus in Cape Colony prior to July 1, 1905, in framing statistical returns, 5 per cent. was added to the declared Customs value, an addition supposed to cover the freight, insurance, and commission value inhering in the goods when imported. On the other hand, in Natal the current values under each statistical head are abstracted from the original Customs entries to the nearest shilling in all cases, and the monthly tables are determined by reckoning 10*s*. and over as 1*l*. and discarding fractions of 10*s*. In the case of Rhodesia, a slight further difficulty exists in the fact that a small quantity of the goods imported is purchased at coast ports such as Beira, while others of the same class are purchased in Great Britain or in countries where they are manufactured or produced. The sale price of the former necessarily includes freight, insurance, shipping and landing

dues, as well as the importer's profits, while the value of the latter is returned as the sale price in the country of origin in accordance with the South African Customs Regulations, and excludes such items as freight, insurance, &c. In the case of Cape Colony, when goods are purchased in the open market and exported to another member of the Customs Union, the cost price in the country of origin is obtained if possible; if not, one-third of the local value is deducted to equalise with goods which have not left bond. This is done for the purpose of distributing the duties equitably among the colonies.

Australia.—In the case of the Australian Commonwealth, the value of the goods is taken to be the fair market value in the principal markets of the country whence the goods were exported. Ten per cent., as covering insurance, freight, &c., is added to such market values for statistical purposes.

Canada.—In the case of Canada, the Canadian Customs Law requires that importers of dutiable goods shall enter them for duty purposes at the fair market value at which similar goods are sold for home consumption in the ordinary course of trade in the principal markets of the country of export, and at the time of export direct to Canada. The declared values are subject to review at the ports of entry by appraisers, and subsequently at Customs headquarters by the checking branch. Any changes, however, which may be ordered to be made for Customs purposes by such appraisers or by the checking branch are not recorded for statistical purposes. Respecting free goods, the values given in the Canadian returns are those declared by the importers, and represent, as a general rule, the price paid for the goods in their condition ready for shipment to Canada from the country of purchase.

With reference to the definition of the term 'current prices,' it may be added that the Customs authorities of Cape Colony have, the Committee are informed, dealt with the question of differential values which appear in the declarations as the result of a closed market. By a 'closed market' is meant a case where one importer has a preferential position as the agent for some article which he is able to obtain at a lower rate than any other importer. The Customs authorities, however, require that the value of goods imported should be returned by all for duty purposes at the same price—namely, the open-market price—and consequently the agent of any firm has to pay on the same value as other individuals importing at the open-market price. Thus if firms have invoiced goods to their agents at the cost of production, the Customs authorities refuse to accept such a declaration of value.

Exports.—Similarly, with regard to the estimation of the value of exports, a declaration is required from the exporter of the value of goods shipped, but in this case greater use is made of official values. One serious difficulty consists in the fact that many goods are shipped on consignment for sale, and their value can only be determined when the goods are marketed. This practice of shipping on consignment prevails, the Committee are informed, to a considerable extent in the case of colonial produce, such as cattle, wool, and other articles, the value of which may be considerably more or less than what was estimated by the exporter at the time of shipment.

C. *Determination of the Country of Origin and of Destination.*

Most goods other than raw material obtain their value from more than one country; the raw materials coming, for example, from one or more countries, while the cost of manufacturing is due to another country. There is, however, in many cases a country of origin of sufficient importance for tabulation.

South Africa.—In the case of South Africa, since the establishment of the Customs Union and the granting of preference to the United Kingdom in August 1903, and to Canada at a later date, a special attempt has been made to discover the country of origin of imported goods. The bill of entry in which the goods are recorded must be supported by what is termed 'a certificate of origin,' which, if found to be false, renders the goods liable to forfeiture. Similarly, the Customs Union Regulations require that the destination of imported goods shall be declared with a view to apportioning the share of duty due to each colony, and failure to comply with these regulations renders a person liable to a considerable penalty. The case is interesting as showing the influence which fiscal considerations with regard to preference or with regard to the distribution of internal taxation can have on the development of statistical information; for while, as was pointed out in the previous report, it is practically impossible to determine accurately the real country of origin, it may be granted nevertheless that within limits the requirement of a certificate of origin assists in revealing the movements of goods anterior to their last shipment, and facilitates inquiry with regard to any particular entry. Thus, since the establishment of the Customs Union of 1903, the requirement of a certificate of origin has shown still more clearly that in many cases the invoice produced is merely that of an agent and not of the actual manufacturer of the goods. Such a document cannot with safety be taken as showing the country of origin, and the falling-off in the year 1904 in the percentage of imports of British goods as compared with the figures of previous years is regarded by the South African Customs authorities as due in a measure to the fact that in former years values were credited to the United Kingdom which should properly have been attributed to Germany and the United States.

Australia.—In the case of the Australian Commonwealth likewise an attempt is being made in the forthcoming statistics to distinguish the country of origin from the country of shipment. Some of the Australian States have for a considerable number of years made the distinction. It should be added, however, that the Customs authorities of the Commonwealth do not attach much value to the distinction, inasmuch as it is stated that the information is in most cases only pushed one stage further back, and no attempt is made to distinguish the origin of the raw or half-manufactured goods from that of the finished product.

Canada.—As regards Canada, the Committee are informed that in respect of the origin of goods no accurate record is attempted. The country in which they are purchased and whence they are invoiced to Canada is treated in the tables of trade and navigation as the country from which the goods are imported. Nevertheless, with regard to goods subject to differential duties a certificate of origin is required.

United Kingdom.—During the past year the British Customs authorities have also attempted to differentiate between the country of origin and the country of shipment, and though the results for a complete year have

not yet been published (for the results of six months *vide* report on 'British and Foreign Trade and Industry,' Second Series, Cd. 2,337), the Committee understand that a considerable amount of information has been obtained regarding, if not the origin, at least the intermediate stages in the exchange of goods.

India.—In the case of India and other parts of the Colonial Empire, the Customs authorities have not as yet attempted to distinguish between the country of shipment and the country of origin.

In dealing with the general question of distinguishing the country of origin from the country of shipment, it is necessary to recognise the difficulty and limitations which beset inquiry, and care will be required in interpreting the information obtained, but the attempt on the part of several large communities of the British Empire to collect this information is to be welcomed. It directs attention to the highly complex character of modern international trade, and it will assist the investigation of the source and development of particular articles. This is important, as much of the value of import and export statistics consists in the light which they throw on the production and distribution of particular commodities.

Destination of Exports.—Several colonies endeavour to obtain the ultimate destination of exports, but it is difficult to place reliance on the declarations made. Thus, for example, in the exports from the West Indies, it is known that some of the goods invoiced to New York are destined for Canada. Again, in the case of exports forwarded on consignment, the ultimate country of destination is often other than that which is declared. Thus much of the trade from India to Hong Kong is trade with China, though in part also with Japan, the Philippines, and the Pacific Coast of America. Similarly, consignments of rice and wheat forwarded to Egypt are largely to await orders at Port Said for delivery in western ports, while cargoes of Dutch sugar are shipped to the West Indies to await orders for American and other ports

D. *Classification of Articles of Import and Export.*

Uniformity of classification is almost as important as uniformity in the system of valuation. At one time, owing to the great economic differences between the several countries comprised, the quest for a uniform classification for the British Empire might have seemed futile. Now, however, natural and political developments have led to a considerable approximation in the classification adopted, at least by the self-governing colonies, and in this case it would seem as if the differences which still remain might be removed with advantage both to the individual countries and to the Empire as a whole. In the case of the Crown Colonies and Dependencies much also could be done to improve the classification, and to adapt it to a general classification for the whole Empire. What is required is the adoption, as far as possible, of a common detailed alphabetical list, which should form the foundation in all cases. At present such a list appears in all the important States within the Empire save India, and its absence there diminishes considerably the convenience and usefulness of the Indian statistics. At the same time it is necessary that the common list should be detailed, for the value of import and export statistics consists to a large extent in the information provided with regard to individual articles. At present many of the colonial returns suffer

from lack of differentiation in classification, especially in the case of the Crown Colonies, and in consequence much of the value of the information is lost. On the other hand, in the case of the self-governing colonies, particularly the Australian Commonwealth, a large amount of valuable detail, excellently arranged, is presented for the information of the public. The point to be emphasised is that while it is necessary to limit detail, greater attention than heretofore must be paid to secure differentiated knowledge which is of value for commercial and industrial purposes.

Again, as in the case of the Annual Statement of Trade of the United Kingdom, and also as in the Commonwealth statistics and those presented in the Annual Register of Cape Colony, the countries to and from which articles are imported and exported should be recorded under each article. It is important, also, that a detailed classification of countries should be adopted. Thus, in the Canadian statistics, the value of the information afforded is diminished by the fact that on the one hand the countries of import and export are not shown in the most detailed list of articles, and on the other that the countries of import and export are themselves insufficiently differentiated. Thus, for example, exports and imports from the several South African States are merged under a general head of 'British Africa.' In this same list the differentiation of articles is defective; for example, it is impossible to ascertain the number of horses, cattle, sheep, pigs, &c., respectively imported from the several countries, since the figures are lost under the general classification of 'Animals.' The comparison of the Canadian with, for example, the Australian import and export statistics brings out the advantages which would be obtained from a common system of classification, not only of articles, but of countries. One of the greatest reforms which can be achieved with regard to Imperial statistics is an agreement on a common classification. At the same time it will be recognised that while it is desirable that a common alphabetical list of commodities and a common list of countries should be adopted, it is clearly out of the question that the immense cross-tabulation which this would involve should be published *in extenso* by all the colonies and dependencies. The exact means by which the desire for detail and the necessity for compactness should be reconciled cannot be discussed now in detail; the main consideration is that every class of goods which is imported on a sufficient scale, or is of sufficient special interest, should be distinguished on a uniform classification, and the principal countries from or to which it is imported or exported given, in some such way as in the Trade and Navigation Returns of the United Kingdom.

E. *Recent Changes affecting Import and Export Statistics.*

Apart from certain particular changes which have been brought to the notice of the Committee, and are recorded hereafter, attention may be drawn to developments in two directions, which have affected and will affect considerably the comparability, if not the accuracy, of colonial statistics. On the one hand there has been the growth of larger Customs Unions, such as the Australian Commonwealth and the South African Customs Union. On the other hand there has been the extension of colonial tariffs and the development in Canada, South Africa, and New Zealand of preferential duties. This latter development has necessitated inquiry regarding the country of origin as distinguished from the country

of shipment. At the same time it may be remarked that, while particularisation and differentiation have been extended in the colonial Customs lists, this movement has, owing to the comparative similarity of colonial tariffs, assisted in approximating to one another the classifications of the several colonies. It may be said that there has been considerable progress towards uniformity within several of the natural local groups and federations, and this is a condition anterior to the larger consolidation which would be realised by a common classification, system of registration, valuation, &c., for the Empire.

The Committee are informed of the following changes :—

South Africa.—In Cape Colony—

(1) Prior to 1885, 10 per cent. was added to all declared values for statistical and Customs purposes. The amount added was then reduced to 5 per cent. This was removed for Customs purposes in 1898, but remained for statistical purposes till June 30, 1905, since which date nothing has been added to declared values.

(2) Up to the year 1898 the declared value was taken to be that at the port of shipment, whereas since that year the value is that of the place of purchase, and does not include the cost of bringing to the port of shipment.

(3) From the year 1889 the destination of imported goods has been recorded.

(4) Up to 1903 the country of origin was recorded as given by the importer without any steps being taken to ascertain its correctness. Since 1903 a certificate of origin has been required.

In Natal—

(1) Up till January 1899 the values were the actual cost at the place of shipment *plus* 5 per cent., whereas the present system gives for statistical purposes, to the nearest 1*l.*, the value in the open market at the place of purchase, including the cost of packing and packages, but not including agent's commission unless it exceeds 5 per cent., with no addition.

(2) In 1901 the statistical heads of imports were considerably elaborated. Prior to that date the main heads contained the values of many articles since separately shown.

(3) Similarly, as elsewhere in the Customs Union since 1903, the certificate of origin is now required with regard to dutiable goods.

There has now (from July 1, 1905) been established a South African Customs Statistical Bureau in Cape Town whose business is to collect and publish the statistics of South African external trade, and also of the internal trade between the five colonies, and to act as a clearing-house for the allocation of the receipts of duties among the colonies. This will tend to bring the statistics of all the colonies up to a uniform standard, and will improve their accuracy and comparability. In doing this there will necessarily be changes in methods and in classification. The alteration begins in the middle of the year. Great care will be necessary in comparing statistics before and after this date, and it is to be hoped that full and explicit explanations of all changes will be given in the forthcoming publications.

Australia.—The establishment of the Australian Commonwealth in 1901 has led to an even closer co-ordination of the Customs than in South Africa.

As a result, a common tariff, including New South Wales, which had hitherto been a free-trade country, has been established, and a common statistical method adopted. In 1904 the first annual report of the import and export trade of the Commonwealth was published. Since September 1903 a record of the transhipment trade from the Commonwealth to foreign ports has been made. In the forthcoming statistical volume the country of origin of imports as distinguished from the country of shipment will be shown.

New Zealand.—New Zealand has the same classification of goods as the Australian Commonwealth. The adoption of the preferential system by New Zealand in 1903 has likewise involved inquiry as to country of origin as distinguished from the country of shipment.

Canada.—The Committee have been informed that there have been no changes within the last twenty years in the method of valuing goods for importation or exportation, nor has any change been made in the method of ascertaining their origin or destination, save in so far as goods subject to preferential rates of duty are concerned, in which case a certificate of origin is required.

India.—Since January 1898 the rupee has been maintained at the rate of 15 rupees to 1*l.*, and the value of imports and exports since that date is shown in pounds sterling In comparing these figures with earlier years, allowance has to be made for the fluctuations in the rate of exchange.

F. *Comparability and Accuracy.*

Owing to the differences already referred to which exist in the methods of the self-governing colonies in estimating and classifying imports and exports, any attempt to determine the accuracy of such statistics by means of comparison is apt to mislead. At first sight it might appear that the exports of, for example, Canada to Australia should correspond with the imports from Canada recorded in the statistics of the Commonwealth, allowance being made for the differences due to cost of freight, insurance, &c. But the difficulties experienced in recording the origin of goods—for example, goods in the Australian returns may be classified as American when they are Canadian, or as Canadian when they are British—and the uncertainty in the valuation of exports make it clear that the existence of a considerable variation in the respective returns is no real evidence of inaccuracy, but only of incomparability. Moreover, in addition to these causes of incomparability is the fact that a common statistical year has not yet been adopted. In Australia the statistical year, as in Cape Colony, is the calendar year. In Canada the statistical year closes on June 30 ; in Trinidad and Jamaica on March 31. In Bermuda the statistical year is the calendar year. In India the statistical year closes on March 31, in Ceylon the calendar year is adopted. Such diversity increases the difficulty of comparison, which is, however, in certain cases obviated owing to the publication of monthly statements of imports and exports. Also, it is evident that goods exported at the close of one year from South Africa to Australia will be recorded in the imports of the next year in the statistics of the Australian Commonwealth.

G. *Suggestions as to Reform.*

(1) It will be recognised that within the British Empire there is a greater possibility of establishing common statistical methods than is

likely to exist among separate foreign countries. In recent years the attainment of this object has been materially forwarded by the establishment of the Australian Federation and the South African Customs Union. The question of common statistical practice throughout the Empire deserves therefore to be discussed further, and it is important that it should receive attention at the colonial conferences, and that there should be an interchange of views with the object of reaching common methods of classification, of estimation of value, and of recording the origin and destination of goods.

(2) It would be of considerable advantage if an annual report on the trade of the Empire were published on a scale sufficiently large to present in considerable detail the trade of the several colonies and dependencies. The statistical abstract for the British Empire, issued for the first time in 1905, is a movement in this direction, but much more detailed information is required than can be given in a report of such small compass. Further, it is important that in such a report a clear statement should be given as to the differences for which allowance must be made when comparing the statistics of the several colonies. It would also be possible to indicate the gaps in existing information. Such a report would undoubtedly conduce to forwarding the adoption of common statistical methods and practice so far as they can be realised.

(3) It is of great importance that meanwhile local developments towards uniformity such as have taken place in Australia should be carried forward. Thus in South Africa it will be a step in advance when a Year-book showing the trade of the South African Customs Union on a scale similar to the Year-book of the Trade of the Australian Commonwealth is published. Again, in the case of the West Indies there is great need for the establishment of closer Customs relations and for the issue of a joint annual report showing in detail the West Indian trade. At present in the West Indian returns there is an absence of uniformity in classification and a lack of differentiation. Again, a common system should be adopted in India, the Straits Settlements, and the other Asiatic possessions of Great Britain. On the whole, information regarding the trade of the Crown Colonies is very imperfect, and inquiry should be made by the Imperial authorities as to how far it would be possible to establish a system throughout the Crown Colonies and Dependencies which would be uniform, and which might also give the detailed information at present lacking.

(4) It is important that a prefatory note should be given in the case of the statistical returns of each colony, explaining the system of valuation and registration of origin and destination, stating whether transhipment and transit trade, bullion, specie, and bunker coal, &c., are included or excluded, and affording any other comment which may assist the proper interpretation of the statistics.

(5) Inasmuch as import and export statistics present only one aspect of the trade of a nation, and as the proportion which the import and export trade bears to the internal trade varies considerably in different countries, it is important, both for the purpose of obtaining a more reliable criterion of trade and production of each colony, and for the establishment of satisfactory comparisons as to the productive power of the several States comprised in the Empire, that import and export statistics should be supplemented by a system of statistics showing the internal trade and production of each colony. Several of the British

colonies have attempted this in the annual report which they furnish on agricultural and industrial productions. It is clear, however, that great care must be taken in order to avoid the counting of the same wealth several times, owing to the different processes of manufacture which wealth undergoes. For the present the Committee desire, however, only to direct attention to the importance of this matter from an Imperial point of view, in the hope that at some time it may be possible to establish an efficient census of production, agricultural and industrial, within the Empire.

(6) A common statistical year should be established.

The Committee render cordial thanks to the Customs authorities of the several self-governing colonies for information which they have afforded in regard to methods of collecting the returns of imports and exports, and also to the Colonial Office for information with regard to the Crown Colonies.

Age of Stone Circles.—Interim Report of the Committee, consisting of Mr. C. H. READ (*Chairman*), Mr. H. BALFOUR (*Secretary*), Sir JOHN EVANS, Dr. J. G. GARSON, Mr. A. J. EVANS, Dr. R. MUNRO, Professor BOYD DAWKINS, *and* Mr. A. L. LEWIS, *to conduct Explorations with the object of ascertaining the Age of Stone Circles.*

THE stone circle known as the 'Stripple Stones,' situated on Bodmin Moor, Cornwall, on the slopes of Hawkstor, was selected by the Committee as a site upon which to conduct excavations this year. The necessary permission was kindly given by the landowner, Sir William Onslow, subject to the area disturbed by digging being made good. A very careful and systematic exploration of the circle was made in June, a preliminary examination having been made earlier in the year by Mr. Balfour and Mr. Gray. As previously at Arbor Low, the Committee were fortunate in securing the services of Mr. H. St. George Gray, who was placed in charge of the excavations, which lasted a fortnight, and which were very satisfactorily organised and conducted. He received much kind assistance from the Rev. Vernon Collins of Blisland. Some twenty or more trenches were dug in various directions, especially along the fosse, which was carefully explored, it being for the most part poorly defined on the surface. In spite of a very thorough search, relics were disappointingly scarce, a few flint flakes and some wood at a low level alone being found. There was a total absence of metal, as was the case at Arbor Low. A very careful contoured survey-plan of the circle has been made by Mr. Gray, who has also surveyed and photographed some of the other circles in the neighbourhood. Owing to the late date at which the excavations were completed, the full report, which will give all details in regard to the work and a complete description of the circle, is not yet to hand, and will be presented next year.

The Committee ask to be reappointed, with balance in hand.

Anthropometric Investigation in the British Isles.—Report of the Committee, consisting of Professor D. J. CUNNINGHAM (*Chairman*), Mr. J. GRAY (*Secretary*), Dr. A. C. HADDON, Dr. C. S. MYERS, Mr. J. L. MYRES, Professor A. F. DIXON, Mr. E. N. FALLAIZE, Mr. D. RANDALL-MACIVER, Professor J. SYMINGTON, Dr. WATERSTON, Sir E. W. BRABROOK, Dr. T. H. BRYCE, Dr. W. H. L. DUCKWORTH, Mr. G. L. GOMME, Major T. MCCULLOCH, Dr. F. C. SHRUBSALL, Professor G. D. THANE, *and* Mr. J. F. TOCHER.

THE Committee have now drawn up a list of dimensions of the human body suitable for measurement. This list contains all dimensions that have hitherto been most usually measured, and some additional dimensions which the Committee consider to be important. The list does not profess to be exhaustive, and other dimensions may be added in subsequent reports. The object of the Committee is to define the points between which the usual dimensions are taken with as much precision as possible, so that all observers may be able to get results which are comparable with one another. It is not suggested that the whole of the dimensions on this list should be measured on each individual by every observer. Each observer can select from the list the particular dimensions he wishes to study.

The chief object of anthropometric measurements may be stated to be the determination of correlations between the different characters of the human body, and between such characters and their environment. The collection of sufficient data to enable the statistician to determine all these correlations will require the co-operation of many observers, and it is obvious that if these observers adopt different methods of measurement, the value of their work will be very seriously impaired. If a standard method of measurement is prescribed, with the authority of the British Association, this evil will be to a great extent obviated. The Committee propose, when their work is sufficiently advanced, to draw up schedules suitable for specific purposes, such as the measurement of school-children, the study of groups of people in selected districts, &c.

In the list are embodied definitions of the anatomical terms made use of, and explanatory notes directing how the dimensions are to be measured. It is proposed in the next report to supplement these directions by illustrations of the human figure, having marked upon them the points between which the dimensions are to be measured. Photographs of the human model are in course of preparation, but it was not possible to get blocks made in time for insertion in this report. An alphabetical list of the definitions is also given at the end.

The Committee, if reappointed, propose to determine and describe the most suitable instruments to be employed to measure the dimensions in the standard list.

They also propose to prepare lists of physiological and psychological characters suitable for measurement, and finally to give a list of the environmental influences which are most deserving of being noted, along with observations on the physique.

Several meetings of the Sub-Committee have been held during the year

The Anthropological Institute has presented to the Lord President of Council a memorial praying that the recommendations of the Physical Deterioration Committee, having reference to an Advisory Committee, an Anthropometric Survey, and a Register of Sickness, should be carried into effect. This memorial is supported by the Childhood Society, the Sociological Society, the head-masters of most of the public schools, and many other influential persons.

The Committee again beg to thank the Anthropological Institute for providing them with headquarters and granting permission to hold meetings in their rooms.

The Committee desire to be reappointed, with instructions to continue the work indicated in the above report. The grant of 10*l.* made to the Committee last year has now been expended. The Committee consider that the work which they are carrying out will be of the greatest value in standardising anthropometric work in this and possibly in other countries. If the work is to be effectively continued a somewhat larger expenditure than hitherto will be necessary. The Committee, if reappointed, ask for a grant of 30*l.*

Standard List of Anatomical Dimensions.

A. Cranium.

The *Cranium* is the part of the skull which forms the protective bony covering for the brain.

Diameters (Calliper measurements).

1. *Maximum length.*—From the most prominent point of the *glabella*, or prominence in the mid-line between the two eyebrows, to the most distant point in the middle line on the back of the head, known as the *occipital point*. The fixed point of the callipers is first applied to the glabella and kept there, while the other point is moved over the back of the head (occiput). Care must be taken to observe that the fixed point has not moved off the glabella during the measurement, and that the callipers have not been deflected from the median vertical plane. The pressure of the points of the callipers on the head should be as much as can be comfortably borne by the person under examination.

2. *Maximum breadth.*—Measured wherever it can be found above the plane of the earholes. The callipers may be held in a vertical or in a horizontal plane and moved about until the maximum diameter is ascertained, the observer being careful to keep the points of the callipers exactly opposite to each other, *i.e.* in the same vertical and horizontal planes. The pressure of the points on the head should be such as can be comfortably borne by the person under examination.

3. *Minimum frontal breadth.*—The minimum diameter obtainable by the callipers, held with their points in the same plane and with the maximum comfortable pressure, between the *frontal crests*, the ridges of bone which may be felt curving upwards and backwards on either side of the cranium immediately above and to the outer side of the orbits if the forehead be grasped between the finger and thumb.

Tape Measurements.

4. *Maximum circumference.*—Measured by passing the tape over the glabella in front and the occipital point behind.

5. *Longitudinal arc.*—Measured with the tape in the vertical plane from the *nasion*, which is the bottom or deepest part of the depression between the forehead (glabella) and the nose, to the *inion* or external occipital protuberance; a prominence on the under aspect of the back of the head, in the middle line, at the point where the curved outline of the back of the head meets the outline of the back of the neck.

6. *Transverse arc.*—Measured over the vertex of the head and between the two pre-auricular points, in a vertical plane when the eyes are directed to the horizon. The *pre-auricular point* is the point immediately in front of the tragus, or the little projection of the ear which lies in front of the earhole.

Radii (Gray's auricular radiometer).

These radii may be considered to pass from the mid-point of the bi-auricular diameter to the various points indicated in the median longitudinal arc of the cranium. They are all to be measured with contact (*i.e.* without perceptible pressure between the point of the instrument and the skin of the head).

7. *Vertical* (which gives the auricular height of the cranium).—From the mid-points of the earholes to the top of the cranium, measured in a vertical plane when the eyes are directed to the horizon.

8. *Frontal.*—(*a*) From the earholes to the most prominent point of the glabella; (*b*) from the earholes to the ophryon.

The *ophryon* is a point in the middle line of the forehead between the prominence of the glabella and the place where the frontal curve begins. It is usually very obscurely marked. The ophryon can also be found by taking the centre of a line drawn across the narrowest part of the forehead.

9. *Maximum frontal.*—From the earholes to the most prominent point on the frontal curve.

10. *Occipital.*—From the earholes to the occipital point.

11. *Inial.*—From the earholes to the inion.

B. Face.

The *face* is the part of the skull which lies below the fore portion of the cranium. It is composed of the jaws and other bones which are arranged around the cavities of the orbits, nose, and mouth.

Calliper Measurements.

1. *Upper face length.*—From the nasion to the edge of the gum between the two upper central incisor teeth. A contact measurement.

2. *Total face length.*—From the nasion to the lower edge of the point of the chin. A contact measurement.

N.B.—In connection with these measurements of face length state the condition of the incisor teeth.

3. *Maximum inter-zygomatic breadth.*—The maximum diameter between corresponding points on the opposite zygomatic arches. The pressure used is to be as much as can be comfortably borne by the person under examination.

The *zygomatic arch* of the skull can be felt stretching forwards from a point in front of the tragus or prominence in front of the earhole to the most prominent part of the cheek.

4. *Maximum inter-malar breadth.*—The maximum diameter between the cheek-bones just below the angles or points of junction between the outer and lower parts of the rims of the orbital openings. A contact measurement.

5. *External orbital breadth.*—Maximum diameter between the outer margins of the orbits. A contact measurement.

6. *External ocular breadth.*—The diameter between the two *external canthi*, or outer angles of junction, of the eyelids. A contact measurement.

7. *Internal ocular breadth.*—The diameter between the two *internal canthi*, or inner angles of junction of the eyelids. A contact measurement.

N.B.—The last two measurements are to be taken when the eyes are open.

8. *Gonial breadth.*—The diameter between the extreme outer points of the angles of the lower jaw. This measurement is to be taken with the maximum comfortable pressure.

Tape Measurement.

9. *Orbito-nasal.*—From the same points as No. 5, the tape passing lightly over the nasion.

Radii.

All these are to be measured with contact only.

10. *Upper nasal.*—From the earholes to the nasion.
11. *Mid nasal.*—From the earholes to the lower border of the nasal bones in the middle line.
12. *Lower nasal.*—From the earholes to the point of the nose.
13. *Alveolar.*—From the earholes to the margin of the gum between the two upper central incisor teeth.
14. *Mental.*—From the earholes to the point of the chin.

C. Nose.

Calliper Measurements.

All these are to be measured with contact only.

1. *Nasal height.*—From the nasion to the *subnasal point*, or angle between the septum of the nose (*i.e.* the partition between the nostrils) and the upper lip.
2. *Nasal depth.*—From the subnasal point to the most projecting point on the tip of the nose.
3. *Nasal length.*—From the nasion to the point of the nose.

4. *Nasal breadth.*—The greatest diameter, measured without pressure, between the wings of the nose.

5. *Nostril length.*—The greatest antero-posterior diameter of the nostril.

6. *Nostril breadth.*—The greatest diameter taken at right angles to the diameter of greatest length.

D. Ear.

Calliper Measurements.

To be taken with contact only.

1. *Length of the ear basis.*—The length of the line drawn from the front upper insertion point of the auricle to the front lower insertion point (E F, figs. 1 and 2).

Fig. 1.

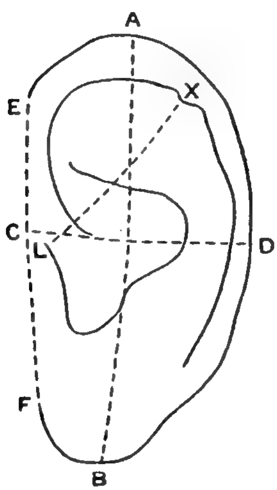
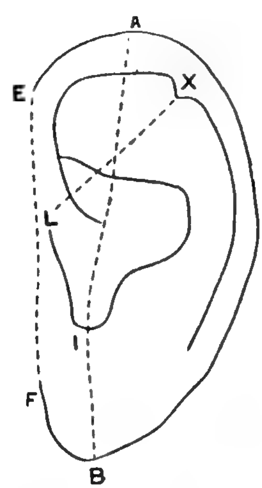


Fig. 2.



2. *Greatest length of the ear.*—(A B, fig. 1.) From the highest to the lowest point of the auricle.

3. *Greatest breadth of the ear.*—(C D, fig. 1.) The maximum diameter at right angles to the length-line from the ear basis to the hinder border of the auricle.

4. *Distance from the Darwinian tubercle to the upper border of the tragus* (X L, figs. 1 and 2).

The prominence in front of the earhole is the *tragus*; the prominence behind the earhole is the *antitragus*. The narrow interval between and below these prominences is the *incisura intertragica.*

The *Darwinian tubercle* is a small projection very frequently present on the free edge of the folded border of the hinder part of the ear near the summit of the auricle. It is the morphological apex of the ear.

5. *Distance from the highest point of the ear to the bottom of the incisura intertragica* (A I, fig. 2).

6. *Length of the lobule of the ear.*—From the bottom of the *incisura intertragica* to the lowest point of the auricle.

E. Trunk and Limbs.

Measurements from the Ground.

The subject is to be measured in the erect attitude, with his eyes directed to the horizon, his heels firmly planted, and the pads of his feet just in contact with the ground. All measurements to be made without boots, it having been found that allowing for the height of the heel of the boot introduces serious errors. All are contact measurements.

1. *Stature.*

2. *Height of the supra-sternal notch*, or the depression between the inner ends of the collar bones (clavicles) where they join the breast bone (sternum).

3. *Height of the upper edge of the pubic symphysis*, or point of junction of the two haunch bones in the middle line in front.

4. *Height of the acromion*, or sharp tip of the shoulder. The most lateral point of this is the position whence measurements are taken. It is most easily discovered by feeling from behind forwards.

5. *Height of the extremity of the middle finger.*—The arm being held by the side with the palm of the hand resting lightly on the outer side of the thigh.

6. *Height of the iliac crests*, or curved upper edges of the haunch or pelvic bones. The measurement is usually made to the *iliac tubercle*, a projection on the outer edge of the iliac crest, about one and a half or two inches behind the *anterior superior spine* or rounded projection which forms the anterior end of the crest. The latter is most easily detected by feeling from below upwards.

7. *Height of the anterior superior spine of the ilium.*

8. *Height of the posterior superior spine of the ilium*, the projection at the posterior end of the iliac crest. This is not easily felt, but the position of these spines is indicated by dimples in the skin above the buttocks, and about one inch from the mid-line of the back on either side.

9. *Height of the upper edge of the great trochanter.*—The outstanding projection at the upper end of the shaft of the thigh bone (femur) immediately external to the hip joint.

10. *Height of the knee joint.*—This measurement should be made on both the inner and outer aspects of the joint, and in each case from the corresponding upper edges of the superior extremity of the *tibia* or inner of the two bones forming the leg.

11. *Height of the tip of the internal malleolus of the tibia.*—The prominent projection on the inner side of the ankle joint, best felt from behind and below.

12. *Height sitting, i.e.* the length of the trunk from the vertex of the head to the lowest points of the ischial tuberosities (height from seat).

13. *Height kneeling.*

F. *Direct Measurements.*

Callipers.

1. *Maximum breadth of shoulders* (bi-acromial).
2. *Distance between two anterior superior spines of iliac bones.*
3. *Distance between the two posterior superior spines of iliac bones.*
4. *Distance between iliac tubercles on iliac crests.*—This will give approximately the maximum diameter between iliac crests.

5. *Maximum diameter between the two great trochanters of the thigh-bones.*

6. *External conjugate diameter of the pelvis.*—From a point behind midway between the posterior superior iliac spines to the upper and fore-part of the pubic symphysis in front.

Measurements of Chest.

Circumference (taken with tape).

Direct subject to hold his arms straight up over his head.

Pass the tape round horizontally at the level of the junction of the fourth rib-cartilage with the sternum or breast bone, then lower arms, and holding tape tightly, note circumference at—

7. *Deep inspiration* ;

8. *Complete expiration.*—This latter is easily attained by asking the subject to count twenty aloud quickly without inspiring.

Before removing tape, mark the level with a blue pencil around the chest.

The fourth rib can be found by noting the projecting ridge on the front aspect of the upper part of the sternum and taking the second rib-cartilage below this.

Diameters (taken with callipers).

9. *Antero-posterior from mid-line in front to mid-line behind* (sternum to spine of dorsal vertebra) at the level of the blue line previously marked.

10. *Lateral.*—The maximum lateral diameter found with the callipers held horizontally and blades tangential to side of chest at the level of the blue line before referred to.

Both these latter measurements should be recorded : (1) in deep inspiration ; (2) in complete expiration.

G. Upper Limb.

1. *Length of the upper arm.*—From the outer margin of the acromion to the lowest point of the external condyle of the humerus, or prominent point on the outer side of the arm bone as it is felt on the back of the limb in the flexed elbow-joint.

2. *Length of the forearm.*—From the lower margin of the external condyle of the humerus on the back of the elbow to the tip of the styloid process or pointed projection directed downwards from the lower end of the radius and easily felt on the thumb side of the wrist. This gives the length of the radius.

3. *Length of the ulna.*—From the tip of the olecranon or point of the elbow to the extremity of the styloid process of the ulna, the pointed projection of bone directed downwards from the forearm on the little finger side of the wrist.

4. *Length of the cubit.*—The elbow joint being flexed, the measurement is made from the tip of the elbow on the back of the arm to the tip of the middle finger.

5. *Length of the hand.*—Measured on the dorsum. The hand being dorsi-flexed, the position of the radio-carpal joint can be determined. Measurement made from this to the tip of middle finger.

6. *Length of the thumb.*—From the base of the metacarpal bone to the tip of the thumb.

7. *Length of the four fingers.*—The three phalanges only to be measured in each case. Measurement to be taken, when the fingers are strongly flexed at the *metacarpo-phalangeal* or knuckle joints, from points on dorsal aspect immediately in front of knuckles.

8. *Breadth of the hand.*—Taken across the knuckles.

H. Lower Limb.

1. *Length of the thigh.*—From upper edge of the great trochanter to the margin of superior extremity of tibia on outer side of knee joint.

2. *Length of the leg.*—From the margin of the superior extremity of the tibia on the *inner side* of the knee joint to the tip of the internal malleolus. This measurement gives the length of the tibia.

3. *Length of the foot.*—Two measurements: (*a*) from back of heel to extremity of second toe, counted from inner side; (*b*) from back of heel to extremity of great toe. Both measurements taken with the foot resting on the ground.

N.B.—A tracing of each foot should be taken.

4. *Breadth of the foot.*—Measured across the heads of the metatarsals (*i.e.* from the prominent point on the inner side of the joint at the root of the great toe to the prominent point on the outer side of the foot at the base of the little toe) when the foot rests on the ground.

Tape Measurement.

5. *Maximum circumference of the calf.*

6. *Circumference of the thigh.*—This is to be taken halfway between pelvis and knee.

I. *Special Measurements.*

1. *Span of arms.*
2. *Weight.*
3. *Colour of hair.* } Standard series of locks of hair and of glass eyes
4. *Colour of eyes.* } have been prepared.
5. *Teeth.*
6. *Finger-prints.*

Alphabetical List of Terms Defined.

Acromion.—The sharp tip of the shoulder. The most lateral point of this is the position whence measurements are taken. It is most easily discovered by feeling from behind forwards.

Anterior superior spine of the ilium.—The rounded projection which forms the anterior end of the iliac crest. It is most easily detected by feeling from below upwards.

Canthi.—Angles of meeting of the two eyelids.

Condyles of the humerus.—The prominent points on either side of the elbow at the lower end of the arm bone (humerus); most easily felt from behind when the joint is bent.

Cranium.—The part of the skull which forms a protective bony covering for the brain.

Darwinian tubercle.—A small projection very frequently present on the free edge of the folded border of the hinder part of the ear near the summit of the auricle. It is the morphological apex of the ear.

External and internal malleoli.—The prominent projections on either side of the ankle joint. These are best felt from behind and below. The external malleolus is formed by the lower end of the fibula, the internal by the lower end of the tibia.

Face.—The part of the skull which lies below the fore portion of the cranium. It is composed of the jaws and other bones which are arranged around the cavities of the orbits, nose, and mouth.

Frontal crests.—If the forehead be grasped between the finger and thumb immediately above and to the outer sides of the orbits, a curved ridge of bone will be felt curving upwards and backwards on each side of the cranium. This is the frontal crest.

Glabella.—Prominence in the mid-line between the two eyebrows.

Great trochanter.—The outstanding projection at the upper end of the shaft of the thigh bone (femur) external to the hip joint.

Iliac crests.—The curved upper edges of the haunch or pelvic bones.

Iliac tubercle.—A projection on the outer edge of the iliac crest, about one and a half or two inches behind the anterior superior spine.

Incisura intertragica.—The prominence in front of the earhole is the tragus; the prominence behind the earhole is the antitragus. The narrow interval between and below these prominences is the *incisura intertragica.*

Inion.—External occipital protuberance; a prominence on the under aspect of the back of the head, and in the middle line, at the point where the curved outline of the back of the head meets the outline of the back of the neck.

Nasion.—The bottom or deepest part of the depression between the forehead (glabella) and the nose; or the most depressed part at the root of the nose.

Occipital point.—The point in the middle line on the back of the head which is most distant from the glabella. It can only be determined by the callipers.

Ophryon.—A point in the mid-line between the prominence of the glabella and the place where the frontal curve begins (usually very obscurely marked).

Posterior superior spine of the ilium.—The projection at the posterior end of the iliac crest. This is not easily felt, but the position of these spines is indicated by dimples in the skin above the buttocks and about one inch from the mid-line of the back on either side.

Pre-auricular point.—Point immediately in front of the tragus, or the little projection of the ear which lies in front of the earhole.

Pubic symphysis.—The point of junction of the two haunch-bones in the middle line in front.

Styloid processes of radius and ulna.—The pointed projections which are directed downwards from the lower ends of the bones of the forearm at either side of the wrist. The former is on the thumb and the latter on the little finger side.

Sub-nasal point.—The angle between the septum of the nose (*i.e.*, partition between the nostrils) and the upper lip.

Supra-sternal notch.—The depression between the inner ends of the collar bones (clavicles) where they join the breast bone (sternum).

Zygomatic arch.—A bony arch on the side of the skull which can be felt stretching forwards from a point in front of the tragus of the ear to the most prominent part of the cheek.

To face page 207.]

Province, &c.	Head-length				Head-breadth				Auricular Height			
	No.	A	σ	C	No.	A	σ	C	No.	A	σ	C
Kena	53	194·79	5·83	2·99	53	143·91	3·80	2·64	27	146·26	3·[illegible]	2·50
Girga	83	194·53	5·83	3·00	83	144·33	4·60	3·19	37	144·78	4·83	[illegible]
Kena and Girga	136	194·[illegible]3	5·83	3·00	136	144·16	4·31	2·99	64	145·41	4·47	3·07
Giza	[illegible]	[illegible]	[illegible]	[illegible]	51	[illegible]	[illegible]	[illegible]	[illegible]	146·77	[illegible]	[illegible]
Dakahlia	109	[illegible]	[illegible]·07	3·15	103	144·64	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Baheira	50	196·82	6·33	3·22	50	144·38	4·40	3·05	20	146·69	4·08	2·78
Sharkia	20	[illegible]	[illegible]	[illegible]	20	[illegible]	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]
Copts	44	[illegible]	[illegible]	[illegible]	44	[illegible]	[illegible]	[illegible]	[illegible]	146·[illegible]	[illegible]	[illegible]
Upper Egyptian Copts [1]	42	192·57	6·87	3·57	42	142·96	5·10	3·51	—	—	—	—
Moslems	369	194·[illegible]	6·09	3·13	369	144·29	4·34	3·01		—	—	—
Mixed	64	[illegible]	[illegible]	[illegible]	64	145·14	[illegible]	[illegible]	43	146·77	[illegible]	[illegible]

Province, &c.	Horizontal Circumference				Cephalic Index				Upper Facial Index				Nasal Index				Auriculo-Gnathic Index			
	No.	A	σ	C	No.	A	σ	C	No.	A	σ	C	No.	A	σ	C	No.	A	σ	C
Kena	19	515·17	14·19	2·66	53	73·94	2·90	3·92	53	48·52	[illegible]	6·92	53	78·90	8·44	10·07	23	102·47	3·35	3·27
Girga	38	517·18	12·75	2·33	83	74·25	3·15	[illegible]	82	47·81	[illegible]	6·19	82	77·77	7·11	9·14	28	103·44	2·77	2·17
Kena and Girga	57	516·61	13·38	2·46	136	74·13	3·01	4·10	135	48·09	[illegible]	6·53	135	78·22	7·68	9·82	51	103·00	3·08	2·99
Giza	14	[illegible]	[illegible]	[illegible]	51	[illegible]	2·16	[illegible]	49	[illegible]	[illegible]	5·50	47	75·[illegible]3	7·31	9·74	20	101·00	4·38	4·34
Dakahlia	[illegible]	[illegible]	12·48	2·28	[illegible]	75·01	[illegible]	[illegible]	106	48·72	[illegible]	[illegible]	103	73·41	7·63	10·39	24	101·24	3·66	3·61
Baheira	11	516·61	10·90	1·99	50	73·12	3·03	4·12	48	49·00	3·32	6·77	46	74·39	6·66	8·96	19	100·68	3·18	3·16
Sharkia					20	73·94	3·03	[illegible]	19	47·56	2·48	5·24	19	76·70	5·78	7·28	6	100·01	1·90	1·90
Copts	17	518·11	12·01	2·19	44	[illegible]	3·18	4·70	42	48·57	3·48	6·55	42	75·77	5·16	10·77	15	100·86	3·53	3·50
Upper Egyptian Copts [1]	—	—	—	—	42	74·43	3·71	4·99	—	—	—	—	—	—	—	—	—	—	—	—
Moslems		—		—	369	74·26	2·86	3·85	—	—	—		349	75·83	7·67	10·12	—	—	—	—
Mixed	16	547·25	20·60	3·76	64	74·10	2·86	[illegible]	62	48·12	[illegible]	5·57	56	79·41	8·21	10·33	25	101·35	4·07	4·02

[1] Including 16 Copts who were not conscripts

Anthropometric Investigations among the Native Troops of the Egyptian Army.—Report of the Committee, consisting of Professor A. MACALISTER (*Chairman*), Dr. C. S. MYERS (*Secretary*), Sir JOHN EVANS, *and* Professor D. J. CUNNINGHAM. (*Drawn up by the Secretary.*)

THE Committee are able to report considerable progress in the elaboration of the above anthropometric material. A further paper has been published by the Secretary in the Journal of the Anthropological Institute (vol. xxxv., part 1), forming a comparative study of the measurements of the modern inhabitants of the provinces of Girga and Ḳena, and of the 'prehistoric' population of Naḳada, who dwelt in the same district seven thousand years ago.

The tables of figures (averages, coefficients of variability and correlation, and probable errors) and the distribution-curves contained in this paper need not be republished here. The general conclusions reached are:—

(*a*) That there is no evidence that the 'prehistoric' and the modern populations of Southern Upper Egypt differ in physical measurement.

(*b*) That the homogeneity of this 'prehistoric' population, so far as it is determinable by the degree of deviation from the average, is the same as the homogeneity of the population who now inhabit a similar region of the Nile valley.

(*c*) That there is great irregularity in the relative correlation of cranial measurements in the 'prehistoric' and modern populations.

A third paper is in course of preparation—investigating the measurements of head-length, head-breadth, auricular height, horizontal circumference, the cephalic index, the upper facial index, the nasal index, the auriculo-gnathic index,[1] (α) in the provinces of Ḳena, Girga, Giza, of Upper Egypt, and of Daḳahlia, Baheira, and Sharḳia in Lower Egypt; (β) among the Copts and Mahomedans of Egypt, (γ) among the Copts of Upper and Lower Egypt, (δ) among the Mahomedan Egyptians whose parents have been born in like (=Moslems) or in different (=Mixed) regions of Egypt or the Soudan.

The preliminary results of this investigation are given in the table facing. The measurements are expressed in millimetres.

The figures under A are the averages, under σ are the standard deviations, under C are the co-efficients of variability. The value of σ is obtained from the formula $\sqrt{\frac{\Sigma d^2}{n}}$, where n is the number of individuals measured, Σd^2 is the sum of the squares of the differences of the individual measurements from the average. The value of C is given by the expression $\frac{\sigma}{A} \times 100$.

[1] This index is 100 times the ratio of (i), the length from the ear-hole to the gums of the upper incisor teeth, to (ii) the length from the ear-hole to the root of the nose.

It remains to be seen whether the differences between the means thus found for different parts of Egypt may be regarded as real, or as accidentally due to an insufficient number of measurements. It will be noted that the most striking deviations in the indices are between the cephalic indices of Giza (73·76) and Daḳahlia (75·01), between the upper facial indices of Sharḳia (47·56) and Baheira (49·00), between the nasal indices of Ḳena (78·90) and Daḳahlia (73·41), and between the auriculo-gnathic indices of Girga (103·44) and Sharḳia (100·01). But the only sure method of deciding whether these differences are real or accidental is by a study of their probable errors. These are in course of being worked out. Meanwhile, however, there can be little doubt that the people of Lower Egypt turn out to be decidedly more leptorhine and more orthognathous than those of Upper Egypt.

Further, an interesting result may be anticipated from an examination of the frequency curves of these measurements, each curve representing the distribution of a given measurement in a different province. Such a study may lead to the recognition of distinct types within the general population of Egypt, supposing it be found that measurements tend to accumulate round certain values which are constant in the various provinces of Egypt.

Archæological and Ethnological Researches in Crete.—Report of the Committee, consisting of Sir JOHN EVANS (*Chairman*), Mr. J. L. MYRES (*Secretary*), Mr. R. C. BOSANQUET, Dr. A. J. EVANS, Mr. D. G. HOGARTH, Professor A. MACALISTER, *and* Professor W. RIDGEWAY.

THE Committee report that of the grant assigned to them at the Cambridge meeting of the Association the sum of 75*l.* has been paid over, as usual, to the Cretan Exploration Fund, and expended in furthering the excavations of Dr. Arthur J. Evans, whose report on the season of 1905 is appended.

The sum of 50*l.*, allocated to ethnological research in 1904 but unexpended, has been put at the disposal of Mr. C. H. Hawes, M.A., of Trinity College, Cambridge, to continue the observations begun by Mr. W. L. H. Duckworth in 1903 on the physical characters of the ancient and modern population of Crete. Mr. Hawes reached Crete in April 1905, spent some time studying the anthropological materials which were brought to light in the excavations of the British School of Archæology at Palaíkastro in Eastern Crete, and made a series of journeys throughout the other provinces of Crete with the object of obtaining further observations of the modern population. His full report is not yet received.

Both branches of the Committee's work continue to promise results of the highest scientific value. The Committee therefore asks to be reappointed, with a further grant of 100*l.*

APPENDIX.

Excavations at Knossos in Crete, 1905. *By* Dr. ARTHUR J. EVANS.

The exploration of the magazines on the Minoan paved way West of the Palace was continued, and further inscribed tablets and sealings were brought to light. It was ascertained that the system of magazines extended Westward along both sides of the ancient roadway. The paved way itself was traced further West, and its principal objective discovered in the shape of a large building running deep into the hillside opposite the Palace. Owing to the magnitude and expense of the work, only a part of this could be explored. A columnar court opening by five spacious doorways into a large hall flanked by a portico formed the eastern section of the building. Beyond were various chambers, a triple staircase, and the beginning of a façade wall on the South, resembling on a smaller scale the west wall of the Palace.

The building belonged to the Later Palace period, but had been reoccupied by poorer settlers in mature Mycenæan times (Late Minoan III.) and divided up into smaller compartments. To the later arrangement belongs a shrine of great interest containing fetish images in the shape of natural stones (stalagmitic blocks) of quasi-human form—a Mother-Goddess and infant, besides other small figures. With these was a rude terra-cotta goat. We have here a primitive anticipation of the traditional Cretan cult of Rhea and the infant Zeus. Impressions of the original wooden columns of the chamber were found, showing fluting in relief, a new feature in Minoan architecture, and of Egyptian derivation. Parts of inscribed tablets and sealings came to light belonging to both periods of the building, and supplying new chronological standpoints. A large seal-impression belonging to the early stratum (Late Minoan I. and II.) showed a horse above a ship with rowers, and illustrates the first importation of horses into Crete.

Further stratigraphical explorations in the west court of the Palace brought to light a floor of the First Middle Minoan period, with numerous vessels in position, including the finest painted vase of this period yet discovered.

An exceptionally rainy season led to the falling in of the second landing of the grand staircase of the palace, and threatened the destruction of the upper flight and balustrades. It became necessary to resort to heroic measures; and, as the wooden props had proved insufficient, I decided to remove temporarily the upper flight, to excavate completely the débris still partly covering the lowest flight of steps, and finally to replace the upper part of the structure at its original level. The removal of the fallen materials below led to the discovery of a second and lower ascending balustrade with sockets containing the charred remains of the original columns. The restoration of these—in stone, however, in place of wood—formed the obviously proper method of resupporting the upper structures. For this very complicated work I secured the services of Mr. C. C. T. Doll, architectural student of the British School at Athens, who has carried it out with great success, the stones of the upper flight of stairs and balustrade being all numbered and reset in their original positions. It was found necessary to extend this reconstitution to the neighbouring Upper Corridor and the Hall of the Colonnades. The result of this very extensive undertaking has been practically to restore the original appear-

ance of what is unquestionably the most monumental feature of the whole building, while at the same time all its ancient elements have been religiously conserved.

In the work of excavation I was throughout assisted, as in previous campaigns, by Dr. Duncan Mackenzie.

The Lake Village at Glastonbury.—Seventh Report of the Committee, consisting of Dr. R. MUNRO (*Chairman*), Professor W. BOYD DAWKINS (*Secretary*), Sir JOHN EVANS, Dr. ARTHUR J. EVANS, Mr. HENRY BALFOUR, Mr. C. H. READ, *and* Mr. ARTHUR BULLEID. (*Drawn up by* Mr. ARTHUR BULLEID *and* Mr. H. ST. GEORGE GRAY.)

THE excavations were reopened at the Lake Village, near Glastonbury, this year, under the joint superintendence of Mr. Arthur Bulleid and Mr. H. St. George Gray. Digging began on May 12, and was continued until June 10, the work covering four weeks, as against three weeks in 1904. Although the weather was exceptionally favourable for digging in marshy ground, a pump was found necessary to keep the trenches free from the water that percolated through the peat. Photographs were taken of hearths and other objects of special interest, and sectional and detailed plans were made of the excavations, as in former seasons.

The areas of ground explored are situated partly at the north-west corner and partly near the centre of the village. At the latter position Dwelling-mounds 51 and 53, partly examined in 1898 and 1904, were completed, and a large tract of level ground lying westward of these dwellings was systematically trenched. This led to the discovery of two additional hut-sites, thus bringing the total number of mounds up to eighty-one. Apart from a few 'finds' of minor importance, the examination of this ground was of a less interesting nature than that previously explored. The ground was not so thickly piled as in many parts of the site, but some exceptionally well-cut and large black oak piles were noticed among them.

The north-west corner of the village was far more productive. Dwelling-mounds 69 and 70 were completely examined, together with the areas of level ground around them, and Mounds 68, 71, 72, and 73 were partly examined.

The following points of interest were noticed in the different mounds :—

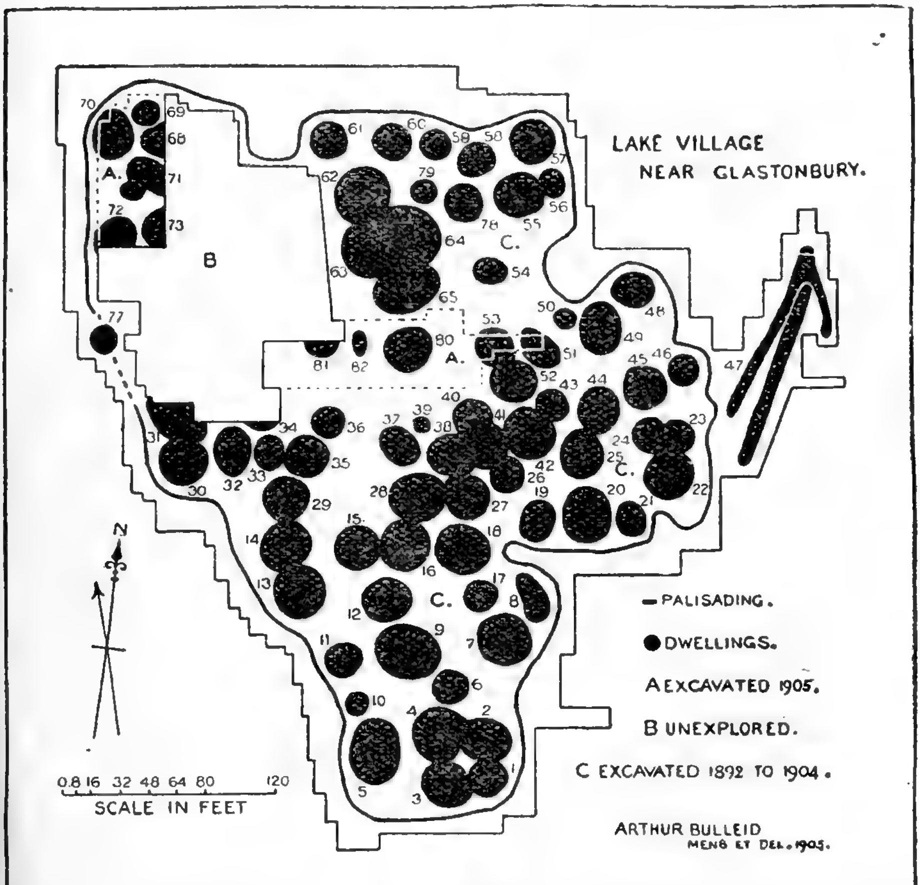
MOUND 69, situated near the N.W. border of the village, N.W. of Mound 68 and N.E. of Mound 70, measured 22 ft. across E. and W. It was composed of two superimposed floors, the total thickness of the clay at the centre being 29 in. The hearth belonging to the first floor was a circular area of baked clay, 4 ft. 8 in. across E. and W. The second floor hearth was less well defined. Near the N.W. margin of the second floor a patch of rubble stone was found, in the position we should have expected to find an entrance pavement. Several fragments of thin grey Roman pottery were dug up near the S.E. margin of the dwelling, immediately under the flood-soil. The substructure underlying the clay was a well-preserved layer of brushwood, arranged for the greater part lengthways E. and W. This was photographed.

The objects of interest found in this mound were :—B 226 (1895),

B 227 (1895), B 380, B 381, B 382, D 72, E 199, E 200, E 202, E 206; H 297, H 298, H 299, H 300, H 301, L 37, M 16 (1895), M 17 (1895), P 132, P 166, Q 42, S 40.

Mound 70.—This dwelling was situated near the N.W. edge of the village, E. of Mound 68, S.W. of Mound 69, and was protected along the W. and N.W. sides by the border-palisading. It was composed of two floors and a series of nine superimposed hearths. The greatest diameter of the Mound E. and W. was 34 ft., and the total thickness of clay at the centre 40 in.

Floor I.—The hearth belonging to this floor was incomplete, being



within 6 in. of the surface of the field. What remained of it was composed of baked clay.

Floor II.—Covering the surface of the floor in several places were distinct signs of the original wood flooring. The hearth was not well preserved. It was composed of baked clay of circular outline, having a diameter of from $3\frac{1}{2}$ to 4 ft. Hearths 3 and 4 were circular areas of baked clay, $3\frac{1}{2}$ to 4 ft. in diameter, without any corresponding floors, the clay extending a foot or two only beyond the base of each. Near the N.W. margin of Hearth 3 and immediately underlying Floor II. portions of a complete infant's skeleton (M 37) were exhumed, and fragments of a second infant (M 38) were discovered at the same level on the E. side of

the hearth. Hearth 5: Except for an extension of clay for 4 ft. along the W. side, this hearth was unaccompanied by the usual clay floor. The hearth was a well-preserved one of baked clay, measuring 4 ft. 3 in. E. and W. and of circular outline. The central part, over an area of 4 sq. ft., was flat; the edge, gradually sinking away to 5 in. below the level of the middle portion, was rounded off. Hearth 7 was of similar shape and size to the last, from which it was separated by a layer of clay 4 in. thick. Hearth 8 was a circular layer of baked clay, 4 ft. in diameter, immediately underlying those above, the centre and margins being at the same level. Near the E. edge several fragments of triangular loom-weights were dug up, accompanied by some wattle-marked baked clay. Hearth 9 was a small circular patch of clay, with a diameter of 3 ft. 9 in. and a maximum thickness of 3 in., of concavo-convex shape in section E. and W., the concave surface being uppermost. This hearth was not lying immediately under the eight above, one-third of its extent being situated outside the N.E. margin of Hearth 8, from the under surface of which it was separated by a layer of peat 2 in. thick. Passing in all directions from the margin of this hearth, over an area of 20 ft. in diameter, was a layer of fire-ash, averaging $2\frac{1}{2}$ in. thick. This layer was found to follow the surface line of the substructure, and contained numerous fragments of charred bone and antler, many of them being worked and ornamented. The layer also produced a large number of fragments of pottery, a fragment of a human humerus (M 36), a quantity of wheat, many baked-clay loom weights (complete and in fragments), masses of charcoal, and, more especially over the southern half, pieces of baked clay showing wattle and finger marks. The first dwelling on this site had evidently no clay floor and was destroyed by fire. A sectional diagram was made of this mound, drawn through the centre E. and W. Under the clay near the palisading S.W. of the mound a large knobbed oak pile was discovered, lying horizontally among the substructure; the top of the knob was charred and incomplete. The pile is of similar shape to many previously discovered, and its original use was presumably to fix the horizontal mortised beams. It was photographed.

Amongst the 'finds' of importance from Mound 70 were:—B 225 (1895), B 383 to 393, B 395, E 102 (1895), E 211, E 223, E 236, E 287, G 23, H 163 (1895), H 304 to 316, I 89 to 92, K 29, L 12 (1895), M 15 (1895), M 36 to 38, P 167, P 168, T 12, W 171, W 172.

Mound 68.—Only a part of the W. margin of this mound was examined; it was found to consist of two floors. The remaining portion will be explored next year.

The objects found in this mound were: B 228 (1895), E 201, H 302.

Mound 71.—Two-thirds of this mound were examined, the remaining part of the dwelling being in ground marked off for next season's work. The mound was composed of three floors, the maximum depth of clay, 3 ft. E. from the hearth, being 18 in. Signs of wood flooring covering the clay were noticed on Floors II. and III. The diameter of the mound N. and S. was 26 ft. Floor I. was of small area, extending a few feet from the margin of the hearth. The hearth was made of gravel, and belonged to both Floors I. and II. It had a circular but irregular outline, and measured 3 ft. 6 in. E. and W. across the top and 5 ft. across the base in the same position. On the second floor a portion of a complete skeleton of an infant (M 39) was found. The substructure was a well-preserved platform, the timber being arranged parallel, with pieces

occasionally placed at right angles. Under the N. and S. quarters of the mound the wood was lying lengthways in an E.N.E. and W.S.W. direction, under the west quarter N.W. and S.E., and at the east side of the hearth in a N.N.W. and S.S.E. direction. Photographs were taken showing the hearth and the timber substructure together.

The chief 'finds' from Mound 71 were :—B 372, B 394, B 396 to 400, C 25, E 235, E 238 to 242, H 317 to 323, H 329, H 330, I 93, I 94, L 38, M 39, P 169, P 170, Q 46, Q 47, W 173, W 174, W 176.

Mound 72 was situated near the W. margin of the village, W. of Mound 73, S.W. of Mound 71, and bounded on the W. side by the border-palisading. It was composed of three floors, the E. and W. diameter through the centre of the mound being 28 ft. The northern half of the mound was the only part explored, the remainder awaiting examination next year. The position of the hearths belonging to Floors II. and III. was determined, both being in a poor state of preservation and placed eccentrically to the middle of the mound. The second floor hearth was made of baked clay, with a few small stones embedded near the centre ; the edge was ill-defined. The hearth belonging to Floor III. was made of baked clay, and its margin could not be determined with accuracy. The W. margin of Floor II. was bounded by a well defined line of wattle-work. Under the clay of Floor I., near the N.W. margin of the mound, a piece of worked oak $6\frac{1}{2}$ ft. long was dug up near the palisading. It was a portion of a much longer beam of split oak, the transverse section being plano-convex. At the complete end the flat surface was notched for 1 ft., so that it could be placed upon and at right angles to a similar beam. Along the centre of the beam was a series of small mortise-holes, averaging $1\frac{3}{4}$ in. long by 1 in. wide, arranged at intervals of from $3\frac{1}{4}$ to 4 in. apart. Similar beams of oak have been found in other parts of the village in former years, in one instance accompanied by the complete hurdle, which was originally fixed upright in the beam. This piece of oak was presumably part of a rectangular building. It was photographed.

The most important objects found in Mound 72 were :—E 246, E 247, H 332 to 334.

Mound 73.—Only a portion of the west side of this dwelling was examined. It was found to be composed of two floors, the total thickness of the clay being 16 in. so far. The substructure consisted of brushwood 1 ft. thick and pieces of timber arranged lengthways in a N.N.E. and S.S.W. direction. This mound awaits completion next year.

The only 'find' of importance was E 245.

Mound 80.—This mound was situated near the centre of the village, W. of Mound 53 and S. of Mound 65. It was composed of a single circular layer of clay, 24 ft. in diameter E. and W., the greatest thickness being 13 in. There was evidence of a baked-clay hearth near the centre, with indefinite outline. Peas were found on the surface of the floor over the western quarter of the mound. The substructure was not strong, the pieces of timber being arranged lengthways in a N.E. and S.W. position. When trenching the ground lying west of this mound several rooted stumps of alder trees were discovered *in situ*. Similar stumps have previously been noticed in the peat near the central parts of the village, and have sometimes shown distinct adze-marks. The leafy peat in the neighbourhood of these stumps was scarcely recognisable as a layer.

The chief 'finds' from Mound 80 were :—F 373, G 24, Q 43, Q 44, S 41, W 170.

MOUND 81.—A small circular mound of clay, 19 ft. in diameter, situated W. of Mound 80 and S.W. of Mound 65. It was composed of two floors, the total thickness of which near the centre was 15 in. Baked wattle-marked clay and wood-ashes were noticed when following the E. and S.E. margins of the dwelling, and were found to extend inwards on the surface of the clay for an average distance of 2 ft. No hearth was discovered on either floor, although there was evidence of fire on both. The substructure consisted of a layer of brushwood. Several rooted alder stumps were found in the peat lying to the south of the mound. The southern half of the mound was the only part explored, the work-shed being situated over the northern edge from the commencement of the investigations in 1892. The complete examination of this dwelling will be postponed until the conclusion of the explorations.

The only objects of interest found in or near this mound were :—H 328, Q 45, W 175, W 178.

MOUND 51.—This mound was of small size, situated in the east central portion of the village, E. of Mound 53 and N.E. of Mound 52. It was composed of five floors. The total depth of clay at the centre was 18 in., the greatest diameter of the mound E. and W. being 22 ft. Floor I. measured 21 ft. E. and W. The hearth consisted of a circular area of baked clay, 3 ft. in diameter, in an inferior state of preservation, and placed eccentrically to the middle of the mound, and south of the summit. Floor II. was of smaller extent, measuring 14 ft. E. and W. Its hearth was of baked clay, situated immediately under that of Floor I., and of similar dimension. Floor III. measured 11 ft. E. and W., and no distinct hearth was discovered belonging to this floor. Floor IV. measured 9 ft. E. and W. The central part of this small area of clay was occupied by a well-preserved circular hearth of stone, averaging 4 ft. in diameter. Floor V. measured 7 ft. E. and W.; fully one-half of the diameter of this area of clay was taken up by a hearth of stone in an excellent state of preservation. Scattered about on or near the S.W. margin of this floor were fourteen slabs of lias, the majority of them lying on the surface of the substructure. Little of importance was found on the floors of this mound except fragments of pottery, and that below the average quantity. Peas were found along the N.W. margin of the clay.

The numbered objects found in or near this dwelling were :—F 369 (1904), H 123 (1894), H 294 (1904), H 295 (1904), P 102 (1894), P 103 (1894), W 64 (1894).

MOUND 53.—This dwelling, situated W. of Mound 51 and N.E. of Mound 52, was composed of three layers of clay, separable with difficulty. The total thickness of the clay near its centre was 15 in., and the greatest width E. and W. 22 ft. Floor I. was indistinct, the surface being mixed with the surface soil, and no hearth was found. Floor II. had its layer of clay better defined. The hearth was made of gravel, with a few pieces of flat sandstone embedded in the surface. The outline was circular and 4 ft. in diameter, convex and irregular, the centre being $3\frac{1}{2}$ in. above the level of the periphery at the base; no bevelling was noticed at the margin. Floor III. had a hearth badly preserved; it was made of baked clay about $3\frac{1}{2}$ ft. in diameter, but the margin was indefinite. Immediately under this there were three other superimposed clay hearths of the same size as the last mentioned. The substructure consisted of layers of brushwood.

The objects found in or around this dwelling, including a comparatively small quantity of pottery, were :—B 379 (1904), E 198, F 370 (1904), F 371, F 372, H 296, H 335 (1898), Q 41 (1904), W 166 (1904), W 167 (1904), W 169.

Short Descriptions of the Relics; all Found in 1905, unless otherwise stated.

Bone Objects. (B.)

225. Polished bone; found to the N. of Mound 70, 1895.

226. Fragment of worked and charred bone; found to the N.W. of Mound 69, 1895.

227. Bone gouge; found near the N. margin of Mound 69, 1895.

228. Perforated metatarsal bone. Mound 68, 1895.

372. Roughly-worked needle, fractured across the eye; length from base of eye to point, 79 mm. The eye was at least 4 mm. across. Mound 71.

379. Perforated head of femur (? human); perhaps a spindlewhorl. Mound 53, 1904.

380. Worked metatarsus, presumably of a small deer; in a bad state of preservation. Mound 69.

381. The upper portion of tibia of horse, the condyles missing. Two perforations (4 mm. diam.) have been made near the top, and on the opposite side a deep notch or slit has been sawn obliquely across the bone to a depth of about 11·5 mm. Mound 69.

382. The upper portion of another tibia of horse, the condyles and other parts missing. Two perforations (diams. 3 and 5 mm.) are still intact and the position of another is observable; on the opposite side two deep transverse notches have been sawn into the bone to an average depth of 15 mm. The slits are about 3·5 mm. wide. Also found in Mound 69. Several of these implements, more or less broken (besides B 381 and B 383, found this year), have been discovered in various parts of the village, but we have not yet been able to determine what their special purpose was, although it has been very vaguely asserted by those who have seen them, and are competent to judge, that they were used in the process of weaving.

383. Another similar, but broken into many pieces. Mound 69.

384. Fragment of charred bone (? bird-bone). One face is ornamented with five representations of dots-and-circles. On another face is a transverse groove, on either side of which are two circular perforations through the bone 3·5 mm. in diam. Mound 70.

385. Piece of cut metatarsal bone, charred, length 29 mm., with a circular transverse perforation 3·8 mm. in diam. Mound 70.

386. Piece of smooth-cut bone (? bird-bone), charred, length 34·3 mm. Max. width at one end, 12 mm.; at other, 8·8 mm. Mound 70.

387. Another similar to last, charred, length 38·5 mm. Cracked lengthwise. Mound 70.

388. Piece of cut metacarpal bone, charred, length 31·4 mm. Max. width at one end, 11·1 mm.; at other, 8 mm. Decorated with one dot-and-circle. Mound 70.

389. Piece of cut metacarpal bone, charred, length 29 mm., with two transverse lateral perforations measuring about 4 mm. in diam. Ornamented on the convex surface by a line of four dots-and-circles. Mound 70.

390. Another similar to the last, charred, length 28 mm., and with similar perforations. Ornamented on the convex surface by a row of three dots-and-circles. Mound 70.

391. A small section of cut bone, charred, length 26 mm. Perforated in two places by circular holes 3·2 mm. in diam. Mound 70.

392. Precisely similar to B 386, but 37·2 mm. long. Max. widths at ends, 12·3 and 9·1 mm. respectively. Mound 70.

393. Eight complete and incomplete objects of charred bone similar in character to those previously described, viz., B 384 to B 392. The eight vary in length in their present condition from 22·5 to 37·7 mm. Six have transverse perforations and five are ornamented with rows of the dot-and-circle pattern. All these little objects, together with many fragments of others, were found scattered over several square feet of space below the clay of Mound 70, on the peaty floor of a habitation which

must have existed before clay had been introduced to this particular mound, and which was probably destroyed by a conflagration. All are charred to a white or cream colour. The plain pieces of cut bone with the natural longitudinal bore are all about the same size; and so are the shorter pieces, viz., those with pairs of perforations bored transversely and laterally and ornamented with the dot-and-circle pattern. It is quite possible that these little objects formed part of a double-stringed necklace, two of the plain 'beads' being threaded horizontally to every ornamental one vertically.

394. Drill-bow made from a rib-bone. Total length on the curve, 259 mm. The perforation at each end is circular and about 4·2 mm. in diam. The flatter end has rounded corners. It has no decoration. Mound 71. A similar drill-bow ornamented with crossed lines, forming lozenges, was found in Mound 44 in 1893.

395. Tibia of animal, sharpened to a blunt point at the slender part of the shaft; length, 148 mm. Mound 70.

396. Polishing-bone, consisting of a metatarsus of red-deer with the condyles wanting. The bone is remarkably smooth, and exhibits evidence of having been considerably gnawed at both ends. Mound 71.

397. Smooth rib-bone showing two cut notches. Mound 71.

398. Three metatarsi of sheep or goat, all more or less worked, two showing signs of scratching all round the shafts, followed by considerable polishing of the surface. Mound 71. (See description of another, B 373, in last year's Report.)

399. About two-thirds of a metatarsus of horse, smoothed for the purpose of polishing or burnishing. Mound 71.

400. The greater portion of a roughly-formed bone needle, broken across the eye, which was approximately 3·7 mm. in diam. Max. ext. width, 6·7 mm. Mound 71.

Crucibles. (C.)

25. Portion of a grey, triangular, hand-made crucible, made from a very fine clay. Mound 71. Portions of several crucibles of this form have been found in the village, but nothing till this year since 1896. A small portion of one (not numbered) was found in Mound 73 this season.

Baked Clay. (D.)

72. Small black disc of baked clay (?), varying in diam. from 19·9 to 20·4 mm.; max. thickness, 3·1 mm. In section it is concavo-convex, the concavity being more pronounced than the convexity. Mound 69.

Sling-bullets.—Only six, in a baked condition, were found during this season, viz., 2 in Mound 69, 1 in Mound 70, 2 in Mound 71, and 1 in trenching N. of Mound 72. One, unbaked, was found in the latter locality.

Balls of Baked Clay.—A large ball, partly perforated, was found on the second floor of Mound 71. Four small balls came from Mound 70, three being partly perforated; they may have been used as the heads of bone awls or pins. Another ball of clay was found on the E. edge of Mound 53.

Unbaked Clay.—A small pellet from the trenching N. of Mound 72.

Loom-Weights.—Triangular, with perforations across the corners:—8 in the peaty layer under the clay floors of Mound 70; 1 found in trenching W. of Mound 53. Of a rounded and narrow form with one perforation:—2 in Mound 70, 1 in Mound 71. Small fragments of many others were found during the season, especially under the clay of Mound 70.

Other Baked Clay Objects.—A large curved piece, which may have formed part of the margin of an oven. Found under the clay of Mound 70, on the floor, which afforded evidence of a conflagration. A plug for stopping up a hole in a hut-wall was found in the trenching S. of Mound 71.

Bronze Objects. (E.)

102. Two pieces of a small bronze finger-ring; ext. diam., 18 mm. Mound 70, 1895.

198. Fragment of thin bronze of concavo-convex cross-section, ornamented with a succession of slight transverse grooves. Mound 53.

199. Small piece of bordering for some perishable material. Mound 69.

200. Small piece of bordering. Mound 69.

201. Fragment of rim of a bronze vessel, length 24·3 mm. The inside is ornamented with a row of short vertical incisions. Mound 70.

202. Rivet-head, diam. 13 mm., height 6·4 mm. The rivet, diam. 2 mm., projects 0·9 mm. below the base of the head. Mound 69.

206. Handle (length 53 mm.), probably of a bronze vessel, and perhaps one of a pair. It is of D-shaped design, the vertical face (length 45 mm.), which followed the neck of the vessel, being slightly convex, whilst the inner surface of the lugs, or ears, of which one remains, is, on the contrary, more decidedly concave, for adaptation to the horizontal curve of the neck of the vessel. The remaining lug is almost circular, max. diam. 13 mm., with a central rivet-hole 1·7 mm. in diam. The handle is of circular section at top and bottom, with a min. diam. of 5·3 mm., and expands to a max. width of 17 mm. This expansion is bounded on either side by a heavy beading, 4 mm. in width, enclosing a sunken field ornamented by an incised representation of a symmetrical curvilinear design, the interspaces being filled by successions of slight grooves arranged horizontally, vertically, and obliquely. Similar ornamentation occurs on the pottery from the village. Found in Mound 69.

211. Small fibula in four pieces, the pin and spring 26·3 mm. long. The catch-plate is not perforated, but the outline of the usual hole has survived as ornament and is clearly traceable, crossed centrally and vertically by two slight conjoined bands. The collar, which in rather earlier fibulæ of this type served to secure the retroflected end of the fibula to the bow, survives in this example as ornament. Mound 70.

223. Slender needle in several fragments; max. diam. of eye, 2·5 mm. Mound 70.

235. Fragment of corroded bronze. Mound 71.

236. Hook (width 9·7 mm.) attached to thin crumpled bronze; the end of the hook tapers to a thin squared edge. Ornamented by a deep groove lengthwise. Mound 70.

237. Two pieces of bordering; max. width, 6·5 mm. Mound 70.

238. Eight fragments of bronze, much corroded and crumpled. Mound 71.

239. Harp-shaped fibula of La Tène type, with a small portion of the tail missing; length, 78·5 mm. Constructed from one piece of metal, with the addition of a short tubular piece of bronze inserted into the coil of the spring. The latter, after twisting round once on one side, arches round the back and completes a symmetrical twist on the other side, turning inwards to form the pin. The catch-plate, being perforated, is strengthened by a vertical but curved strut. A raised band or collar forms part of the ornament on the bow, and is, in this respect, similar to E 211 described above. Mound 71.

240 and 241. Portions of two large rivet-heads; max. diams., 15 and 16 mm. Also several fragments of corroded bronze. Mound 71.

242. Three damaged rivet-heads and several rivets without heads. Also fragments of corroded bronze. Mound 71.

245. Stout but small child's finger-ring, ornamented by a continuous groove round the middle; width at front 3·3 mm., tapering to 1·8 mm. at back; int. diam., 12 mm. Mound 73.

246. Fibula, complete, made of one piece of bronze; total length, 43 mm. The bow is almost straight, the flattened top (max. width 4 mm.) being ornamented with three longitudinal grooves tapering towards the nose or tail of the fibula. One face of the catch-plate exhibits signs of slight incised ornamentation. The coil commencing from the bow makes two twists outwards on one side and, folding under the head of the bow, completes two symmetrical turns inwards before the pin emerges. Mound 72.

247. Bronze chape of scabbard of sword or dagger, the bulbous termination of which is 13·5 mm. in diam. Bronze bordering for the edges of the sheath spring in both directions, and measures 7·8 mm. in average width, being of semicircular section. Several inches of this bordering were observed in the peat in continuation of what now remains, but being in a very fragile condition it could not be removed entire. Found in Mound 72. A similar chape was found in Mound 58 (1896), and is figured in the 'Proc. Som. Arch. Soc.,' vol. 50, pt. 2, Pl. VII., E 107.

Flint. (F.)

369. Worked flake. Mound 51, 1904.
370. Long flake with two worked saw-like edges. Mound 53, 1904.
371. A tiny flake. Mound 53.
372. Flake with prominent bulb of percussion. Mound 53.
373. Large flake with a little secondary chipping. Found in trenching near the E. margin of Mound 80.

In addition to the above, two flakes were found in Mound 53; four in trenching S. and S.E. of Mound 65; two in Mound 70; two, Mound 71; three, Mound 72; one, Mound 73; four, Mound 80; two W. of Mound 80; and one in Mound 81.

Glass. (G.)

23. Piece of blue fused glass of irregular form, to which some corroded bronze adheres. Mound 70. This affords further proof that glass objects were made in the village.

24. Bead of white glass, not quite circular, the ext. diam. varying from 21·2 to 23 mm.; int. diam., 10 to 11 mm. The section of the substance is round. Found in trenching S.W. of Mound 80.

Antler. (H.)

123. Short piece of cut antler; max. length, 45 mm.; max. width, 58 mm. Mound 51, 1894.

163. Piece of worked antler. Found outside the palisading, but near Mound 70, 1895.

294. Plain weaving-comb, having ten small teeth, all more or less broken. Mound 51, 1904.

295. Slender tine of deer, showing signs of having been worked. Mound 51, 1904.

296. Piece of worked antler split down the middle and charred to a bluish-white colour; length, 32 mm. The object has a knobbed head, of which only a small section remains. Mound 53. H 335, mentioned below, is a similar object from the same mound, but the pieces do not join.

297. Two portions of a worked antler. Mound 69.

298. Portion of a roughly-cut but very smooth antler, with a large transverse hole 7·5 mm. in diam. Perhaps a cheek-piece of a horse's bit. Mound 69.

299. A similar but larger piece than H 298, with a perforation in a like position and 6 mm. in diam. Rows of slight transverse scorings are seen all round this object. Between the hole and top on one side a short but deep notch has been sawn transversely. Mound 69.

300. Piece of a tine of antler worked at the point. Mound 69.

301. Piece of worked antler (probably roe-deer). Mound 69.

302. Portion of an unornamented weaving-comb in many fragments. Mound 68.

303. Point of a small tine, charred; length, 72 mm. Ornamented with two transverse grooves at the broad end, and having a large perforation at 7·8 mm. below that end. Mound 70.

304. Another precisely similar to H 303, but 78 mm. long. Mound 70.

305. Another, much damaged. Mound 70. It is quite possible that these three small perforated objects may have been used as pendants for a necklace.

306. Portion of a small weaving-comb, white from calcination. Traces of only four teeth remain, above which are two incised transverse lines enclosing a plain zigzag design. Min. width of handle, 18·2 mm. Mound 70.

307. Point of a tine, calcined, the tip having been bifurcated by a shallow groove, which tapers off from a max. width of 1·8 mm. Mound 70.

308. Piece of smooth antler of oval section, showing saw-marks at the large end; the other end has been broken, and the point is missing. Mound 70.

309. Portion of the handle of a calcined weaving-comb, the teeth entirely deficient. There is a circular hole (diam. 4·8 mm.) at the top for suspension. It is ornamented with fifteen incised dots-and-circles, irregularly arranged. None of the circles are true, owing to the action of fire. Mound 70.

310. Straight piece of tine, bearing clear evidence of having been cut in several

places. Although there is no perforation for attaching the implement to a shaft of wood, it appears to have been intended for a rough spear-head, perhaps used in driving animals. Mound 70.

311. Portion of a handle of a weaving-comb, of a creamy colour, caused by calcination. Ornamented with twelve dots-and-circles, which have been converted into ovals by the action of fire. Mound 70.

312. Fragment of a calcined weaving-comb, ornamented by two transverse and two oblique incised lines; between the latter is a row of three unusually small dots-and-circles; there are also two in the interspace between the transverse and oblique incisions. Mound 70.

313. Portion of a calcined weaving-comb, with seven complete and incomplete teeth remaining; they are unusually small, but the burning has, doubtless, caused shrinkage. Seven dots-and-circles occur, arranged irregularly. Mound 70.

314. Dentated portion of a calcined weaving-comb, unornamented, with six complete teeth remaining. Mound 70.

315. Piece of roe-deer antler, white from calcination. The small projecting tine has been worked to a smooth point, and may probably have been used for decorating pottery. Mound 70.

316. Dentated end of a small calcined weaving-comb, in a very friable and incomplete condition. Mound 70.

317. Large object of antler of red-deer, in many fragments and beyond repair. Oblique scorings and marks of the saw are observable in places. Mound 71.

318. Hammer formed from the base of a red-deer antler, measuring 208 mm. in circumference just above the burr. It shows indications of much use, and was found in several pieces in Mound 71. The hole for the reception of the shaft is of oblong section, measuring on the lower side 26 by 21 mm.; the formation of this hole was started by means of a broad saw, and the work has been clumsily carried out, deep saw-marks extending beyond the margin of the hole to the extent of from 9 to 14 mm. The hole on the other side was formed by the removal of the brow-tine.

319. Portion of a small antler of roe-deer, points missing, but showing saw-marks and other signs of having been used. Mound 71.

320. Tine of an antler worked to a smooth, blunt point, and having a perforation (diam. 6 mm.) at base. Mound 71.

321. Large straight piece of red-deer antler, length 315 mm., somewhat in the form of a truncheon. The part for grasping has been rounded to an average diam. of 23 mm., at the base of which is a roughly-trimmed knob projecting on one side (max. width 47 mm.)—a stop for preventing the implement from slipping from the user's grasp. The head has been sawn off square, and for some distance down the shaft a rectangular section has been maintained, the four sides near the top averaging 33 mm. in width. The head shows little signs of wear or rough usage, and as there is no evidence of its having been used for any beating purpose, we can only surmise that the object was intended for utilization as a handle for a saw or other cutting implement. Mound 71.

322. Short piece of antler with saw-marks at both the squared ends; max. length, 40 mm.; max. width, 41·5 mm. Mound 71.

323. Complete roe-deer antler, length 214 mm. The two branching tines have been worked at the points, and at their junction a circular perforation (min. diam. 3·5 mm.) has been neatly cut. Close to the base the drilling of a hole has been commenced in an opposite direction. Mound 71.

328. Incomplete object of antler, very smooth, and showing signs of prolonged use. Mound 81.

329. Portion of a tine, length 106 mm.; probably a cheek-piece of a bridle-bit. It has a perforation within an inch of each end, both interspaces being ornamented with six transverse, incised, parallel lines, which, however, occur on one side of the object only. Mound 71.

330. Small piece of burnt antler. Mound 71.

331. Portion of a small tine, charred, unornamented. The perforation, if one existed, has been broken away. Similar in other respects to H 303, 304, and 305, and found in the same mound, viz., Mound 70.

332. Small piece of smooth antler. Mound 72.

333. Large piece of antler of red-deer, with portion of one tine projecting. The object has been sawn through in four places. Midway between the 'spring' of the tine and its squared termination a depressed band has been cut all round to the

extent of about 20 mm. in width, the outer coating of the tine being removed to a depth varying from 1 to 4 mm. We have been unable to ascertain for what purpose this large implement was used. Mound 72.

334. Fragment of the handle of a weaving-comb, burnt black. Ornamented with incised oblique lines, forming a lozenge-shaped interspace. Mound 72.

335. Fragment of charred antler similar to H 296, both being found in Mound 53; H 335 in 1898.

Iron. (I.)

89. Small fragment, much corroded. Mound 70.

90. Mouthpiece of a wooden sword or dagger sheath, much corroded; length, 60 mm. The sides are slightly convex, but the ends are expanded into bulbous projections. Mound 70.

91. Pointed iron object, much corroded; length, 55·5 mm. Mound 70.

92. Four pieces, much corroded, probably fragments of a sickle or knife. Mound 70.

93. Iron adze in one piece, but very much corroded, the socket still containing some of the wooden handle; length about 6½ in. Mound 71.

94. Portion of an iron bar of quadrangular section; length, 5⅜ in.; width, 18 mm., tapering to 14 mm.; thickness, 10 mm., tapering to 7 mm. Mound 71. Its purpose is undeterminable owing to corrosion.

Kimmeridge Shale. (K.)

29. An exceedingly fine armlet, complete; ext. diam., 97 mm.; int. diam., 71·5 mm. The lathe-marks on the inside are well defined, whilst the exterior face is ornamented by three deeply cut, continuous parallel grooves—an excellent example of the skill of the lake-dwellers in using the lathe. The grooves vary a little in width. The substance of the armlet is of oval section, and varies in width from 16·1 to 17·1 mm., and in thickness from 11 to 12·7 mm. Found in Mound 70. This is the most important and best-worked object of Kimmeridge-shale that has been found in the village.

Lead and Tin. (L.)

12. Tin weight of Roman type and in the form of a cheese. Found outside the palisading of the village, to the north of Mound 70, 1895. Similar to those which have been commonly found in the county at Charterhouse-on-Mendip, many of which are exhibited in Taunton Castle Museum.

37. Small portion of a tin ring, much corroded. Mound 69.

38. Piece of lead ore. Mound 71.

Human Bones. (M.)

15. Complete human skull (not yet examined). Found in the peat near the W. edge of Mound 70, 1895.

16. Portion of skeleton of young child. Found in the peat near the N. margin of Mound 69, 1895.

17. Part of a child's skull. Found near the last, 1895.

36. Piece of the shaft of a humerus. Mound 70.

37. Portion of complete skeleton of an infant. Mound 70.

38. Portion of an infant's skeleton. Mound 70.

39. Portion of complete skeleton of an infant. Mound 71.

Animal Bones. (N.)

Two or three wheelbarrows-full of fragmentary animal remains were collected from the 1905 excavations. Three dog's-teeth were found on the first floor of Mound 69.

Pottery. (P.)

102. Pot of an unornamented ware, 7½ in. high, with a bead rim. Mound 51, 1894.

103. Part of a pot. Mound 51, 1894.

132. Portion of the mouth (ext. diam. 88 mm.) of a *Roman* vessel of thin, hard, grey pottery. Found on the surface of the peat outside the palisading, near Mound 69, 1895.

166. A few fragments of thin grey *Roman* pottery, found at the base of the 'flood-soil,' Mound 69. Both these Roman 'finds' and the leaden weight (L 22) represent surface objects at the time the village was abandoned, and nothing of Roman workmanship has yet been found on the floors of any of the dwellings.

167. Fragment of rim of a thick pot fractured in two places through circular perforations. There is no evidence whatever that the holes were intended for the reception of leaden rivets. Mound 70.

168. Small pot, complete, but found in two pieces; thick and hand-made, with a bottom which is not perfectly flat. Slightly rounded sides, with straight rim. Height, 38·5 mm.; max. ext. diam., 60 mm. Rounded bottom on the inside. Mound 70. A somewhat similar small pot was found last year (P. 164).

169. Pot in fragments, not yet restored; unornamented. Mound 71.

170. Another, ditto. Mound 71.

A large quantity of fragments of common ware was found, as in previous years, but the proportional number of decorated fragments to those with no ornamentation was below the average this season, as was also the case last year. There was again a paucity of curvilinear designs, but several pieces with chevrons were found. In close proximity to the corn found in Mound 70, fragments of two fairly large but shallow bowls were found, scattered about over several square feet of ground. Neither can be completely restored.

Querns. (Q.)

42. Lower stone of a well-tooled, circular quern; diam., 13 in. Mound 69.

43. Rough piece of a quern. Mound 80.

44. Rough piece of a lower stone. Mound 80.

45. Upper stone of quern in two pieces, showing handle-hole at side. Found in trenching S.W. of Mound 81.

46. Piece of an upper stone. Found in trenching S. of Mound 71.

47. Upper stone in many fragments. Found in trenching S. of Mound 71.

Stone Objects. (S.)

(Other than Spindlewhorls and Querns.)

40. Whetstone of fine sandstone, with pronounced grooves on both faces and scorings indicating prolonged use. Mound 69.

41. Slab of stone of a slaty nature with flat face and of rectangular transverse section; max. thickness, 13·3 mm.; max. length, 110 mm.; max. width, 78 mm.; with rounded and bevelled edges at top and bottom. Found in four pieces (now joined) of about equal size, outside the S. margin of Mound 80. On one face oblique incisions occur, as if it had been used for sharpening purposes; but the peculiarity of the object is that it has been roughly scratched with irregular squares, covering both faces, in chess-board fashion. Its use is at present unknown, and although it has been asserted that it might have been used for some game, the 'squares' are so irregular and indefinite that such a purpose can only be vaguely surmised.

Small rounded Pebbles, probably 'calculi.'—One from Mound 70; one, Mound 71; one, Mound 72; one, W. of Mound 80.

Whetstones, mostly having slightly convex faces.—One from Mound 53; seven, Mound 69; five, Mound 70; six, Mound 71; one, Mound 81.

Other Stone Objects.—Stone muller of somewhat spherical form, Mound 71; another of plano-convex section, Mound 71; ovoid hammer-stone, Mound 53; smooth disc of sandstone, max. diam. 59 mm., Mound 71.

Tusks, &c. (T.)

12. Calcined dog's-tooth, fractured through a perforation measuring 3·9 mm. in diam. Mound 70.

Spindlewhorls. (W.)

64. Shale spindlewhorl, damaged; max. diam., 44 mm.; diam. of hole, 5·7 mm. Mound 51, 1894.

166. Sandstone spindlewhorl; diam., 41·5 mm.; min. diam. of hole, 5·5 mm. Mound 53, 1904.

167. Small, flat, sandstone spindlewhorl. Mound 53, 1904. (Figured in the 'Proc. Som. Arch. Soc.', vol. 50, pt. 2, pl. IX.)

168. Flat white lias spindlewhorl, fractured and repaired; diam., 41 mm.; min. diam. of hole, 5·4 mm. Mound 69.

169. Disc of sandstone measuring 44 by 49 mm., with incipient hole for the purpose of making a spindlewhorl. Mound 53.

170. Half a spindlewhorl of unbaked clay, with hole 6 mm. in diam. Mound 80.

171. Baked-clay spindlewhorl, average diam. 40 mm. Very convex on both faces; max. thickness, 34 mm.; min. diam. of hole, 4 mm. Mound 70.

172. Disintegrated sandstone spindlewhorl; max. diam., 50 mm.; diam. of hole, 6 mm. Mound 70.

173. One-half of a light grey sandstone spindlewhorl; diam., 42·5 mm.; min. diam. of hole, 6·5 mm. Mound 71.

174. Thick stone spindlewhorl; diam., 49 mm.; min. diam. of hole, 8 mm.; thickness, 22·5 mm. Mound 71.

175. Sandstone spindlewhorl, bi-convex, but flatter on one face than on the other; diam., 44 mm.; min. diam. of hole, 4·5 mm. Mound 81.

176. White lias spindlewhorl with flat faces; diam., 40·2 mm.; min. diam. of hole, 7 mm. Mound 71.

178. Spindlewhorl made from a piece of thick pottery slightly concavo-convex in section; average diam., 44 mm.; diam. of hole, 5 mm. Mound 81.

Miscellaneous.

One of the roughly-perforated limpet-shells found in the village was dug up this season in Mound 71.

Red colouring-matter was found between Mounds 51 and 53.

Anthropological Photographs.—Interim Report of the Committee, consisting of Mr. C. H. Read (*Chairman*), Mr. H. S. Kingsford (*Secretary*), Dr. J. G. Garson, Mr. H. Ling Roth, Mr. H. Balfour, Dr. A. C. Haddon, Mr. E. Sidney Hartland, Mr. E. Heawood, Professor Flinders Petrie, Mr. E. N. Fallaize, *and* Mr. J. L. Myres, *appointed for the Collection, Preservation, and Systematic Registration of Photographs of Anthropological Interest.*

A set of photographs by Mr. D. Randall-MacIver, illustrating the processes of pottery manufacture in Upper Egypt, has been registered by the Committee.

The Committee ask to be reappointed without grant.

The State of Solution of Proteids.—Third Report of the Committee, consisting of Professor Halliburton (*Chairman*), Professor Waymouth Reid (*Secretary*), *and* Professor Schäfer. (*Drawn up by the Secretary.*)

The results mentioned in the last report have been published *in extenso* in the 'Journal of Physiology,' vol. xxxi. pp. 438–63, and the work of the past winter has been devoted to the state of solution of Hæmoglobin. This native proteid presents so many known differences from those already

the subject of report that it was considered necessary to investigate its state of solution.

At the outset the difficulty of preparing solutions of crystals not liable to pass into the condition of Methæmoglobin at the temperature of the osmotic experiments had to be overcome, and the work was here much delayed by an unfortunate accident, a newly built still giving water holding traces of lead, which ruined all the earlier experiments.

As the ratio of the extinction coefficients of the solutions in two different regions of the spectrum has been the test of the presence of traces of Methæmoglobin, and as no experiments have been accepted unless the value of this ratio agreed with that given by Hüfner, it is believed that the solutions finally used were free of this modification, and that solutions of Hæmoglobin alone were used for observation of osmotic pressures.

The interesting fact was soon seen that gelatine, though impermeable to the other native proteids used in the previous experiments, is permeable slowly to Hæmoglobin; and since the ultra-microscope showed no more in solutions of Hæmoglobin than in distilled water (again in marked contrast to the appearances with crystallised ovalbumin 'solutions'), it was considered probable that osmotic investigation would prove a state of true solution for Hæmoglobin crystals.

When a parchment membrane was substituted for the gelatine membrane of the former experiments, it was found that solutions of crystals of Hæmoglobin from the dog, the blood corpuscles of which had been thoroughly washed to remove the serum proteids, gave remarkably constant osmotic pressures in relation to the concentrations, and the different values with different samples, so marked in the cases of the other native proteids, were conspicuously absent.

The conclusion is that Hæmoglobin crystals when taken up in water pass into a state of true solution.

A full account will appear shortly in the 'Journal of Physiology.'

Metabolism of the Tissues.—Report of the Committee, consisting of Professor GOTCH (*Chairman*), Mr. J. BARCROFT (*Secretary*), Sir MICHAEL FOSTER, *and* Professor STARLING.

THE present report takes up the work which has been done under the auspices of the Committee since the report of 1904 was drafted. That report dealt chiefly with the metabolism of certain secreting glands, namely, the kidney and the pancreas. Respecting both these glands work of importance had been done in 1903–4. The scope of that work has been enlarged in 1904–5.

The Kidney.—A comparison has been made between the gaseous exchange of the kidneys and the amount of work done in concentrating the urine. The 'work' so done was calculated from the freezing-points of the blood and of the urine by Galeotti's formula.

It usually happens that the work of concentration increases when the volume of urine increases, although the urine is more dilute, but this is not always the case. The following experiment will show that the consumption of oxygen does not bear any relation to the work performed in concentrating the urine :—

Comparison of Gases in Blood from Renal Veins and Carotid Artery during periods of Rest and Diuresis.

Comparison	I.		II.		III.	
Time	1h. 52m.		8h. 54m.		4h. 40m.	
	Arterial	Venous	Arterial	Venous	Arterial	Venous
Oxygen, per cent.	24·2	23·6	20·2	16·5	22·2	17·6
CO_2, per cent.	50·0	50·6	35·9	35·7	38·2	46·0
O_2 exchange per min.	0·9 c.c.		4·3 c.c.		1·3 c.c.	
CO_2 " " "	0·9 c.c.		1·9 c.c.		2·3 c.c.	
Urine per min.	0·02 c.c.		4·9 c.c.		0·18 c.c.	
Work per min., calculated from freezing-points	84 g.c.m.		nil		nil	

In the above experiment there is no concentration during a very active secretion (so far as the relative depression of the freezing-points shows), and therefore the urine may be taken as a simple filtrate in Ludwig's sense; but its secretion is accompanied by a very great consumption of oxygen by the kidney. The amount of energy which is represented by the oxygen in consumption in our experiments is so great, that the work done in concentrating the urine could only form a negligible portion of it.

The call for oxygen depends upon the degree of diuresis, and not the rapidity of the blood-flow. In many experiments the diuresis has not been accompanied by any vascular augmentation, though it has always been accompanied by increased oxygen consumption.

The carbonic-acid output of the kidney does not go hand in hand with the oxygen intake at any given moment, nor is the variation in the former at all so large as in the latter. Over a large number of experiments, however, the carbonic-acid output is approximately equal to the oxygen intake. Probably the want of apparent harmony between the oxygen absorbed and the CO_2 excreted is due largely to the solubility of the CO_2 in the tissues in which it is produced.

The Pancreas.—The carbonic-acid output of the pancreas has claimed the attention of the Committee. A considerable number of experiments have been performed upon the resting pancreas. These may be divided into two classes:—

1st Class. In which the carbonic acid produced is approximately equal to the oxygen taken in.

2nd Class. In which there is a negligible CO_2 production, with a normal oxygen intake.

The 2nd class might be explained either by the supposition that only penultimate products are formed, or that the pancreas was consuming its own CO_2 in the formation of alkali to be subsequently secreted. The latter view seems the most probable on account of the following considerations: (*a*) The gland is taking up an ample supply of oxygen, hence there is no reason why oxidation should be incomplete. (*b*) As much as 300 volumes per cent. of carbonic acid can be pumped from acidulated pancreatic juice (simultaneous titration shows that the alkali is present chiefly as sodium bicarbonate, but partly as sodium carbonate).

The observations of 1904 indicating that flow of pancreatic juice is

accompanied by an increased consumption of oxygen, have been confirmed except in one case, when the arterial pressure, and consequently the blood-flow through the gland, was greatly reduced. In this case the blood in the pancreatic vein was extremely venous, but not entirely deoxidised. The question is therefore raised whether the blood gives up its last traces of oxygen to the tissues as readily as it gives the rest ?

The Submaxillary Gland.—Researches have been performed with the object of discovering the exact influence of the cervical sympathetic nerve upon the gland. The following facts have been ascertained :—

(1) That stimulation of the cervical sympathetic causes no increase of oxygen taken up by the gland.

(2) That stimulation of the cervical sympathetic causes no water to be taken from the blood except as an after effect.

(3) That stimulation of the cervical sympathetic leads to a diminished output of CO_2 from the gland to the blood, and sometimes even to a slight transference of CO_2 from the blood to the gland.

(4) That when the cervical sympathetic and chorda tympani are stimulated together on the one hand, or the chorda alone on the other, with such a strength of stimulus that the flow of saliva in the blood-flow is approximately the same in each case, the following results are obtained for the relative properties of the two specimens of saliva :—

—	Stimulation of Chorda and Sympathetic	Stimulation of Chorda only
Saliva volume	Equal	Equal
CO_2 output to blood . . .	Less	Greater
CO_2 output to saliva . . .	Greater	Less
Total CO_2 output . . .	About equal	About equal
Fixed CO_2 in saliva . . .	Greater	Less
Alkalinity of saliva . . .	Greater	Less
Oxygen intake from blood .	About equal	About equal

It appears that the sympathetic is not either 'secretory' (since its stimulation does not involve the abstraction of water from the blood) or 'trophic' (since its stimulation does not involve increased gaseous metabolism) in Heidenhain's sense. At the same time it has an action (independent of vascular effects) which causes material to be expelled from the cells, not the ducts merely, and a transference of alkali from the blood to the saliva. This greater alkalinity probably accounts for the greater percentage of organic matter in the saliva.

Glands generally.—In so far as the above specimens may be taken as characteristic of secreting glands generally, the outstanding fact seems to be established that the volume of the secretion (*i.e.*, the amount of water which is transferred from one side of the epithelium to the other) is the surest index of the degree of oxidation taking place in the gland, and it is difficult to avoid the conclusion that there is a causal connection between the two phenomena.

Technique.—Certain modifications in technique have been introduced as occasion has arisen.

The Hirudin of Jacobi[1] has proved a most useful reagent for blood-gas work. In experiments upon the pancreas it has been introduced, and its

[1] Obtained from E. Sachsse & Co., Leipsig-R.

use has saved the physiological errors introduced by defibrination of the blood of the animal, whilst for blood-gas analysis it has proved entirely reliable.

It has been found possible to get a satisfactory record of the blood-flow through an organ in two ways :—

(*a*) By causing blood to flow along a recurrent vessel into a tube connected with a bellows recorder, and subsequently returning the blood to the vein from which it came.

(*b*) By momentarily obstructing the flow through the vein when the organ is in a plethysmograph.

A modification of Bohr's blood-gas receiver [1] has been introduced with a double-surface condenser, packed with a freezing mixture. This form of receiver has proved very satisfactory.

Botanical Photographs.—Report of the Committee, consisting of Professor L. C. MIALL (*Chairman*), Professor F. E. WEISS (*Secretary*), Mr. FRANCIS DARWIN, Mr. W. G. SMITH, *and* Mr. A. G. TANSLEY, *for the Registration of Negatives of Photographs of Botanical Interest.*

FORTY photographs have been added to the register since the last meeting. They have been received from various persons, but we would mention in particular a series of photographs by Mr. R. Welch illustrating the coast flora of Ireland, and a number of photographs by Professor Yapp, of Aberystwyth, illustrating some aspects of the vegetation of the Malay Peninsula.

A printed list has been prepared of the photographs so far contributed to the register, and this will be ready for circulation in July.

The recently established Committee for the Botanical Survey of Great Britain contemplates the establishment of a collection of botanical photographs of British vegetation, and it is hoped that that committee will collaborate with the Committee of the British Association by taking over the work of collecting and arranging photographs relating to British vegetation.

Of the grant of 5*l.* made to the Committee 3*l.* 17*s.* has been spent on printing the register, as decided upon last year.

Experimental Studies in the Physiology of Heredity.—Second Report of the Committee, consisting of Professor H. MARSHALL WARD (*Chairman*), Mr. A. C. SEWARD (*Secretary*), Professor J. B. FARMER, *and* Dr. D. SHARP.

Report to the Committee by W. Bateson, M.A., F.R.S.

EXPERIMENTS on heredity in plants and animals have been continued throughout the year.

In *Primula sinensis* the inheritance of the three types of flower, long-

[1] Made by Messrs. C. E. Muller, Orme & Co.

styled, short-styled, and equal-styled, has been worked out, and some facts of importance have been ascertained.

The experiments of the present year have much elucidated the peculiar phenomena seen in the case of the 'walnut' combs of fowls, and we anticipate that this part of the work will shortly be finished. Progress has also been made with the subject of colour-inheritance in fowls, and some new lines of experiment have been started.

The colour phenomena following reversion in sweet peas, hitherto very complex, have been a good deal simplified by this year's results. It is likely that another season's work will make it possible to provide a fairly complete scheme of inheritance in this case.

In May, 1905, a Report to the Evolution Committee of the Royal Society was published, dealing with the work up to the end of 1903 in detail, and giving incidentally conclusions derived from the work of 1904. A Report up to the end of the 1905 season will be prepared next winter.

Several fresh inquiries have been begun. Of these the chief relate to the inheritance of sex in Lychnis, and of the direction of the spirals, right or left, in the fruits of *Medicago.*

The Structure of Fossil Plants.—Interim Report of the Committee, consisting of Dr. D. H. Scott (*Chairman*), Professor F. W. Oliver (*Secretary*), *and* Messrs. A. C. Seward *and* E. Newell Arber.

All the money expended (33*l.* 18*s.* 3*d.*) has been devoted to the purchase of sections of Coal-measure plants, largely from the new locality at Shore-Littleborough, Lancs, recently opened up to scientific investigation by Mr. Sutcliffe.

The specimens obtained fall under three heads :—

For Mr. Arber, about fifty sections of a new ribbed *Sigillaria.*

For Professor F. W. Oliver, fifty-nine sections of Pteridospermous seeds, mainly *Lagenostoma physoides.*

For Professor F. E. Weiss, forty-one sections of *Stigmaria,* including a new species.

The sections are now in the hands of these three gentlemen for purposes of investigation.

We hope to embody some account of the scientific results attained in our final report.

The work will be carried on during the coming year, and the Committee desire to be reappointed, and also to apply for leave to retain the balance of 16*l.* 1*s.* 9*d.* now in the hands of the Chairman.

They further wish to apply for an additional grant of 20*l.* for the pursuit of the investigation, and recommend that Professor F. E. Weiss be added to the Committee.

The Training of Teachers.—Interim Report of the Committee, consisting of the BISHOP OF HEREFORD (*Chairman*), Mr. J. L. HOLLAND (*Secretary*), Professor H. E. ARMSTRONG, Mr. OSCAR BROWNING, Miss A. J. COOPER, Mr. ERNEST GRAY, *and* Dr. H. B. GRAY.

THE Committee recognise that the problem of the training of teachers is at least as pressing in South Africa as it is in England at the present time; but local conditions are entirely different, and a Report prepared from the standpoint of English education would be of little assistance to South African administrators and teachers in the solution of their own particular training problem. Moreover, the time at the disposal of the Section for the discussion of Reports will be exceedingly short, and no adequate discussion will be possible. Under these circumstances, therefore, your Committee propose to make their formal Report at the York Meeting of the Association next year, and in order that they may be able to do so they respectfully request the Council of the Association to reappoint them for a further year.

On the Origin and Progress of Geodetic Survey in South Africa, and of the African Arc of Meridian. By Sir DAVID GILL, *K.C.B., F.R.S.*

[Ordered by the General Committee to be printed *in extenso.*]

[PLATES II. AND III.]

THE first geodetic operation in the southern hemisphere was that of the Abbé de la Caille, who, in 1752, measured an arc of the meridian 1° 13′ 17″ in length.

The result was anomalous, as apparently showing, by comparison with arcs measured in the northern hemisphere, that in the southern hemisphere the earth's polar radius is greater than its equatorial radius.

Improbable as this result appeared, La Caille's reputation for accuracy stood so high that a definitive settlement of the question was necessary.

The work of revision was undertaken by Mr. (afterwards Sir Thomas) Maclear, His Majesty's Astronomer at the Cape. After spending much labour in satisfactorily identifying La Caille's points of observation, Maclear connected them by a chain of triangulation which he extended southward to Cape Point and northward to Koeberg and Vogel Klip, including La Caille's four principal points.

He could not identify the terminal points of La Caille's base, but he measured a new base-line, 8·1 miles in length, nearly in the site of La Caille's base, and connected it with the points of his own and La Caille's triangulation. The measurement of the base was begun on October 30, 1840, and with continuous work it was completed on April 3, 1841. The measurement of the angles of the triangulation was begun in October, 1841, and the field-work, including the astronomical observations, was completed in March, 1848.

A full account of the work, edited by Sir George Airy, was published

in two volumes, by order of the Lords Commissioners of the Admiralty, in 1866. Maclear's arc has an astronomical amplitude of 4° 37′ in latitude, and proves, within moderately narrow limits, that the form of the earth in the southern hemisphere is similar to that in the northern hemisphere.

The astronomical amplitude of La Caille's arc proved to be very nearly correct, but a large local disturbance of the direction of gravity at La Caille's northern station, amounting to more than 8″ of arc, accounted for the greater part of the apparent error of his work.

Nothing in the way of further systematic accurate triangulation was done in South Africa till 1859, when a triangulation of the southern coast of Cape Colony and British Kaffraria was set on foot, the Colonial Government being urged thereto by the demands of the Admiralty for the accurate determination of points on the coast-line in connection with the hydrographic survey which they were about to undertake, in order to correct the then very inaccurate and defective state of the charts of the coast. It was evident also that such a survey would furnish means of better connecting the detached property surveys through that part of the Colony. The work was entrusted to Captain Bailey, R.E., aided by one sergeant and thirteen rank-and-file of the Royal Engineers, five of whom were selected from the Ordnance Survey of England. The cost of the work was borne by the Colony ; it was begun in 1859 and concluded in 1862. The party embarked at Algoa Bay in the 'Waldensian,' *en route* for England. The vessel struck upon the rocks off Struys Point and became a total wreck. On board were the instruments, drawings, original observation books, with full abstracts, calculation books of every kind, all complete in every respect. They were all lost, and have never been recovered. Fortunately, copies of 'abstracts of angles' had been supplied to the Admiralty Surveyor engaged on the Coast Survey, other abstracts of angles with a diagram to the Surveyor-General in Cape Town, and from these and sundry copies sent to the Government of British Kaffraria and to private individuals an account of the work was compiled by Captain Bailey, and printed in a report presented to the Cape Parliament in 1863.

Soon after appointment to my present position at the Cape in 1879 I began to study the general question of the geodetic survey of South Africa. The traditions of my office appeared not only to justify, but to demand, that some portion of my time and attention should be devoted to this work. Sir Bartle Frere was then Governor of the Cape Colony and High Commissioner for South Africa.

From his experience of administration in India His Excellency thoroughly realised the advantages and the necessity for accurate survey, and the true economy of basing all future surveys upon a principal triangulation of such accuracy that its results might be considered definitive for all future time, and he gave my recommendations his strongest support.

These recommendations embraced a plan for a gridiron system of chains of principal triangulation extending over Cape Colony, the Orange Free State, Natal, and the Transvaal.

The political and financial situation in the Cape Colony at the time rendered it difficult for Ministers to take action during the session of 1880. But soon afterwards I had, through Sir Bartle Frere's kindness, the opportunity of meeting Sir George Pomeroy Colley, when His Excellency

passed through Cape Town on his way to resume his governorship of Natal. In October 1880 I visited Natal as the guest of Commodore (now Admiral of the Fleet) Sir Frederick Richards, on his flagship, H.M.S. 'Boadicea,' in order to make preliminary experiments connected with the telegraphic connection of the longitudes of Aden and the Cape of Good Hope, and to further discuss with Sir George Colley the steps which should be taken in connection with the proposed survey. The result was that Sir George Colley took immediate steps to forward the project by addressing a message to the Legislative Council proposing to place a sum of 2,000*l.* on the estimates of 1881 for the initial expenses of the proposed operations, 'the expenditure to be contingent on the Cape Government undertaking to join in the proposed survey and bear its share of the general expenses connected with it.' One of the last documents addressed by Sir George Colley to the Legislative Council was a message of thanks for their reply to the above proposal; this message was dated December 21, 1880. A few days afterwards Sir George Colley left his seat of Government, never, alas! to return.

But it was not until I again visited Natal in August 1881, in connection with the Cape-Aden longitude operations, then in progress, that further advance was made. I took advantage of the opportunity to reopen the survey question, with the result that Colonel Mitchell (afterwards Sir Charles Mitchell, G.C.M.G.), who was then administering the Government of the Colony of Natal, decided to write to the Secretary of State, asking that the War Office might be applied to for the services of a captain and subaltern of Royal Engineers, with a party of non-commissioned officers and men, to begin the survey, and I was requested to prepare the specifications for the necessary instruments. Finally, in January 1883 I succeeded in arranging an agreement between the Governments of the Cape Colony and Natal to undertake the principal triangulation of both colonies as a joint work.

A detachment of Royal Engineers, consisting of Captain Morris, R.E. (now Colonel Morris, C.B.), Lieutenant (now Lieutenant-Colonel) Laffan, R.E., and fourteen non-commissioned officers and men, finally reached Durban in June 1883, and work was at once commenced by selecting, laying out, and measuring the base line in Natal. The field-work of the geodetic survey of the Cape Colony and Natal was completed in October 1892, and the results, including a rediscussion of Maclear's triangulation, were published and presented to the Cape Parliament in 1896. The completion of this work enabled me to carry out a complete re-reduction of Bailey's survey, as a complete chain of Bailey's best triangles was included in the work of the geodetic survey. Many errors in Bailey's published work were detected, and the whole was reduced to systematic agreement with the geodetic survey. The results form vol. ii. of the 'Geodetic Survey,' which was published in 1901.

The details of both works will be referred to later on. The main object to be kept in view was how to extend these operations in such a way as best to increase their geodetic value. In vol. i. of the 'Geodetic Survey' just mentioned (p. 157) I wrote on this point as follows:—'Looking forward to the practical and possible progress of geodesy, the question may be asked, *Should not the progress made in geodetic survey in South Africa be regarded as the first step in a chain of triangulation which, approximately traversing the thirtieth meridian of east longitude, shall extend continuously to the mouth of the Nile?*'

On the immense importance of the proposed work as a geodetic operation it is unnecessary to dwell; the measurement of an arc of meridian 65° in amplitude would be a gain to geodesy so vastly important as alone to justify its inception.

But this is not all. By an additional chain of triangles from Egypt along the coast of the Levant and through the islands of Greece the African arc might be connected with the Roumanian and Russian arc, so as to form a continuous chain of 105 degrees in amplitude, extending from Cape Agulhas to the North Cape—the longest arc of meridian measurable in the world.

This object I have ever since constantly kept in view, and I have lost no opportunity of forwarding it.

Meanwhile, during the later stages of the field-work in Cape Colony and Natal, questions connected with the delimitation of the boundary between British and German territory in S.W. Africa had sprung up. That boundary is the subject of an agreement between the Governments concerned which was signed at Berlin in July 1890. It is defined to the south by a line commencing at the mouth of the Orange River, and ascending the north bank of that river to the point of its intersection by the 20th degree of east longitude, and, running then northwards along the meridian to the point of its intersection by the parallel of 20° south latitude, then eastward along that parallel to the point of its intersection by the 21st degree of east longitude, and thence northwards to the point of its intersection by the parallel of 18° south latitude.

Mr. Bosman had executed a chain of triangles from the neighbourhood of Vryburg westwards to the 20th meridian. This chain rested on a base line measured by Major Laffan, of which he also determined the orientation and the latitude and longitude of one of its extremities by astronomical observations, exchanging telegraphic signals for the latter purpose with the Cape Observatory. It should be mentioned to Mr. Bosman's credit that, although his work was paid for by the Bechuanaland Government at the tariff rates of secondary survey, Mr. Bosman made it his ambition to render the work fit for incorporation as an integral part of the geodetic survey. He procured a 10-inch theodolite at his private cost, and came to the Observatory for practical astronomical training, and he made a rigorous least square solution of the complex figures of which some parts of the chain were composed.

The work of Bosman and Laffan practically settled the position of the 20th meridian in the neighbourhood of the Orange River, and as far northwards as Reitfontein; but administrative difficulties soon arose further northwards, where there appeared to be an uncertainty of 18 or 20 miles as to the true position of the 20th meridian.

A temporary settlement of outstanding difficulties was made by Germany agreeing to withdraw from certain points near the boundary in dispute, and Great Britain undertaking that Bosman's triangulation should be extended northwards to the 22nd degree of south latitude.

Matters were in this state of friendly suspense when I visited England in 1896, and was consulted by the Colonial Office as to the means necessary to carry this promise into effect.

I then pointed out that from Reitfontein (the northern point of Mr. Bosman's survey) the 20th meridian crossed the Kalihari Desert, a country so flat and waterless that it would be difficult, if not impossible, to triangulate it. If, therefore, the triangulation had to be extended

northwards, it would have to be carried through German South-West Africa, and it was unreasonable to expect that a work which would thus be of such advantage for the survey of German territory should be carried out entirely at British expense. I was accordingly instructed to proceed to Berlin to represent these views, and endeavour to come to some provisional agreement with the Foreign Office there on the lines above indicated.

The result of that mission was a joint proposal that Bosman's triangulation should be connected at both its eastern and western extremities with the geodetic survey of Cape Colony and continued northwards to the 22nd parallel of south latitude, thence along that parallel to the 21st degree of east longitude, and for a short distance northwards along the latter meridian. The cost of the survey north of Reitfontein to be equally divided between the Governments concerned.

Major (afterwards Lieut.-Colonel) Laffan, R.E., was appointed English Commissioner, and Lieutenant Wettstein German Commissioner, and the direction of the work was placed in my hands by both Governments concerned.

Lieutenant Wettstein at a later stage of the work was replaced by Lieutenant Doering.

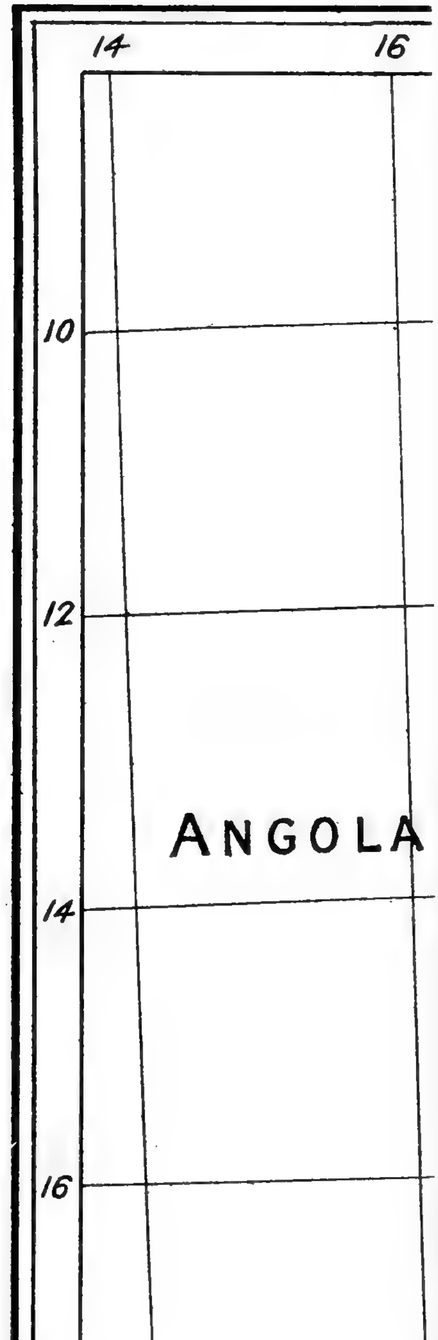
The Commission assembled at Reitfontein, Gordonia, in November 1898. The Commissioners encountered the greatest obstacles in their work on account of the difficult and waterless character of the country—in fact some of the trig. points were forty miles distant from the nearest water supply; in other places much time and labour were required to clear trees and scrub, and the work was not brought to a close till October 1903.

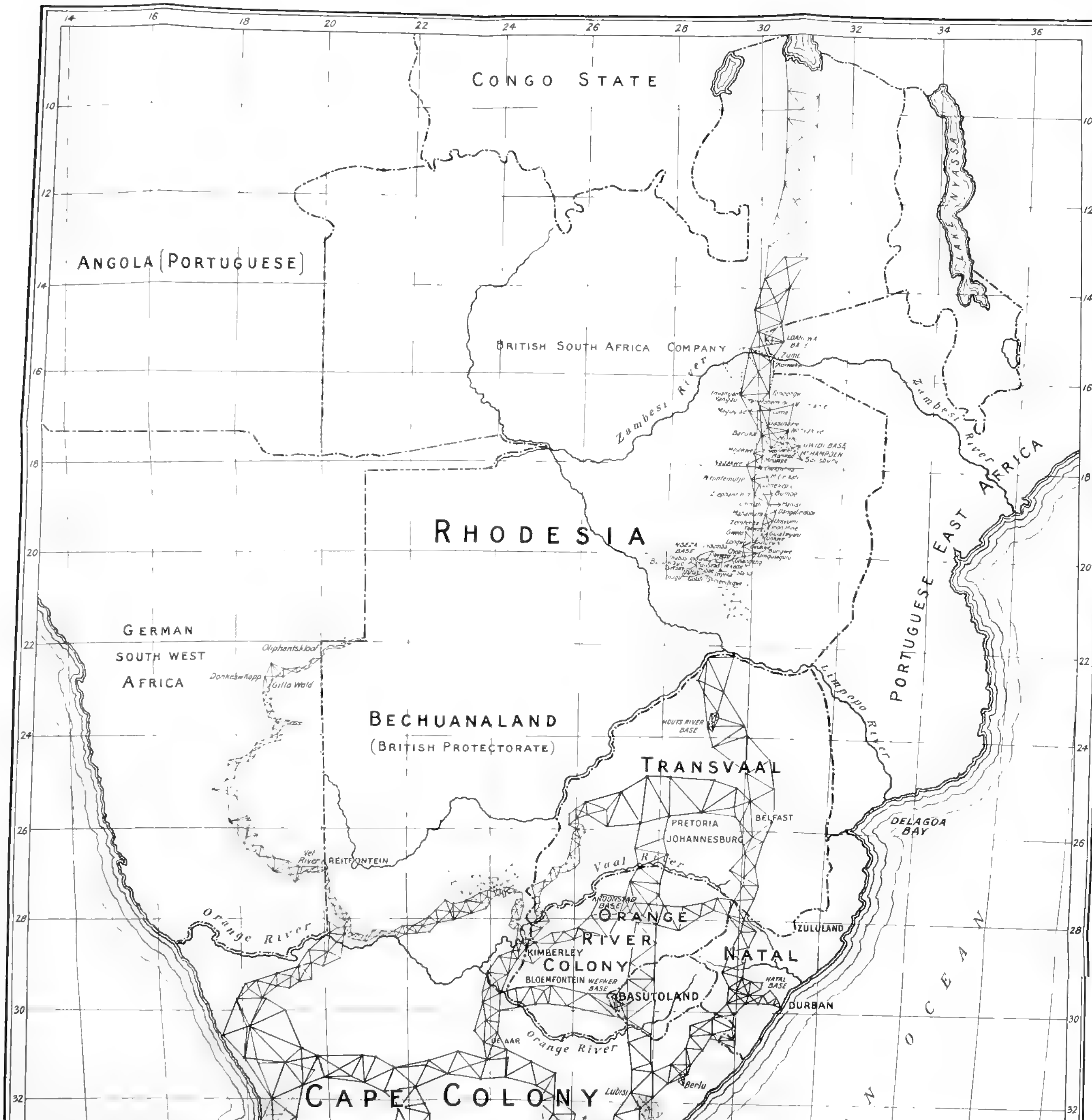
Meanwhile Mr. Alston was employed by the Government of Cape Colony in connecting the eastern and western extremities of Bosman's triangulation with the geodetic circuit in Cape Colony. This work was completed in 1900.

Meanwhile, also in 1894, I urged on the late Cecil Rhodes the great scientific and practical value of commencing geodetic work in Rhodesia, and of the possibility of that work becoming part of the greatest arc of meridian in the world. Such an arc would also form a basis for the co-ordination of all detached surveys through a most important and still unsurveyed part of Africa, and be a fit precursor of his great scheme for a Cape to Cairo railway.

Mr. Rhodes was very sympathetic, but declared that Rhodesia was in the first place in need of roads, bridges, and other essential works; that he felt its resources must first be directed to these objects, but in the course of two or three years he hoped to set the work on foot. When, later (in 1897), Earl Grey as Administrator of Rhodesia, on my strong representation, sanctioned the commencement of the work, Mr. Rhodes not only took a deep interest in it, but when it had nearly reached the Zambesi he promised that funds would be provided to carry it to Lake Tanganyika. The field-work in Southern Rhodesia was carried out under Mr. Alex. Simms, formerly a computer at the Cape Observatory, who had there qualified as a surveyor, and who is now in charge of one of the field-parties engaged in the geodetic survey of the Transvaal and Orange River Colony. Time does not permit a description of the many difficulties encountered in the work on account of rains, smoke of grass fires, &c., which left only a few months available in each year for field-work.

British Association, 7





Illustrating Sir David Gill's Paper on the Origin and Progress of Geodetic Survey in South Africa, and of the African Arc of Meridian.

The work was suspended during 1902 on account of the war, and recommenced in 1903. I selected Dr. Tryggve Rubin as officer in charge of the work in Northern Rhodesia. He had been a member of the Swedish-Russian expedition for measurement of the Spitzbergen arc of meridian in the summer of 1901, and was leader of the expedition which completed that work in 1902. After residence for three weeks at the Cape Observatory he sailed for Chinde on April 29, 1903. He was joined by Mr. Tyrrell McCaw as chief assistant, who sailed from the Cape for Chinde on October 5 of the same year. There remained several points requiring occupation south of the Zambesi, and some others had to be re-selected, as further reconnaissance had shown them to be unsuitable for the northward extension. Dr. Rubin found, as Mr. Simms had found, extraordinary difficulties presented by haze, smoke, and heavy rains, and much of the first year was occupied with work connected with the Anglo-Portuguese boundary. Dr. Rubin's last report brings his statement of its progress up to April 1905.

In July 1902, during a visit to Lord Milner, then Governor of the Transvaal and Orange River Colony and High Commissioner for South Africa, I submitted plans and proposals for an ordnance survey of these Colonies. The original desire of Lord Milner was to have the topography of the country carried on *pari passu* with the principal triangulation, or, rather, to immediately follow the latter work in localities where maps were most urgently wanted. But in consequence of a proposal of the War Office for the formation of a central office for the execution of a topographic survey of South Africa, to which all South African Colonies were to contribute, I urged that the principal triangulation of the Transvaal and Orange River Colony should be first of all executed, in order to bring up their state of survey to a level with that of the Cape Colony and Natal.

That course was adopted, and the work has been in steady progress ever since, under the energetic directorship of Colonel Morris, R.E., C.B., pressure of other work having compelled me to limit my offices to those of scientific adviser.

So much for the history of the work. Let us now look at the results.

The large map Plate II. shows the whole of the triangulation accomplished in South Africa ; the different divisions of the work will be sufficiently evident from their geographical position.

Although the whole of the triangles shown in the Transvaal and Orange River Colony have been selected and beaconed, the whole have not yet been completely measured. Diagrams 1 and 2, Plate III., show the chains which have been completed and reduced in the Cape Colony, Transvaal, Orange River Colony, and Natal, with the exception of the astronomical observations at the points to which no figures are attached. For these points the astronomical observations have been made, though not yet reduced. The whole of the Bechuanaland and Damaraland triangulation, and its connection with Maclear's arc, and the triangles near Kimberley have also been reduced. The survey in Southern Rhodesia has been completely reduced.

In Rhodesia the two northern triangles have not been observed, or, rather, the details of their measurement have not yet reached me, but the rest have been preliminarily reduced for the purposes of the present paper.

The following are the base lines which have been measured, and from the following table it will be seen that they control, more or less

directly, arcs of meridian, and they are therefore given in the order of these arcs, reckoning from west to east :—

Along	Name of Base	Latitude	Length. Feet	Measured with
19° E. Long.	Zwartland Base	33°	42819·065	Colby compensating bars
	S. Damaraland Base	—	Not yet measured	
	N. Damaraland Base	23	31029·97	Steel and brass Jäderin wires
25° E. Long.	Port Elizabeth Base	34	6000·000	Troughton & Simms steel bars
	Kimberley Base	28½	5999·185	Do. do.
	Ottoshoop Base	25½	57212·39	Nickel steel Jäderin wires
28° E. Long.	Wepener Base	30	71048·14	Do. do.
	Kroonstad Base	28	64919·67	Do. do.
	Ottoshoop and Belfast Base	26	See footnote	—
The great Meridian Arc along 30° E. Long.	Natal Base	29½	10800·457	Troughton & Simms steel bars
	Belfast Base	25½	62316·92	Nickel steel Jäderin wires
	Houts River Base	23½	--	Do. do.
	Inseza Base	20	62019·673	Steel and brass Jäderin wires
	Gwibi Base	17½	71165·270	Nickel steel and steel Jäderin wires
	Loangwa Base	15	57087·61	Nickel steel Jäderin wires.

The northern side of this arc is checked both by Ottos-hoop and Belfast base.

With exception of the first bases, measured by parties who used the Jäderin apparatus for the first time – *i.e.*, on the Inseza and North Damaraland bases—the probable error of base measurement is about 1 : 1,000,000. I estimate the uncertainty of the length of the Inseza and North Damaraland bases at 1 : 100,000.

The chief errors do not lie in the discordances of the repeated measurements of the base, but in the standardisation of the wires. But when the most complete methods are taken for standardising the wires, the chief source of error is the error of the absolute length of the standard bar, which cannot be relied upon, even after the most rigorous comparison, within less than 1 : 1,000,000. Full details of the basis of these conclusions are published in Vol. i. of the 'Geodetic Survey of South Africa,' with reference to the bases measured with the Troughton & Simms apparatus, and show the accidental probable error of measurement to be from 1 in 3 to 5 millions.

In regard to the Gwibi base, which enters into the great arc along the 30th meridian, having regard to the fact that the standardisation of the wires employed was carried out not on the field, but at the Cape Observatory, before and after the base measurement, the following particulars may be given :—

In the centre of the base-line site a ground standard of 400 yards

was laid down. Its terminals were marked by fine holes in brass blocks, fixed on concrete pillars 2 feet square and 4 feet deep, founded on rock.

Each pair of wires was compared a number of times on November 3, 4, and 5 with the 400-foot ground standard before measurement of the base, and again on December 22 and 24 after measurement of the base.

The length of the standard base for the measurements in November was computed from the results of the Cape comparisons in the preceding August and September, and those of December from the Cape comparisons in the following January.

The results are given in the following table, in three columns, for comparison—

a. From all measures.

b. From measures with wires not used in the base work.

c. From measures with the old wires only, and excluding the later measure with the C, D pair (D having been used on the base).

Length of 400-foot Ground Standard.—A.

1900	Wires	*a*	*b*	*c*
		mm.	mm.	mm.
November 3, 4, and 5, with lengths derived from Cape comparisons in August and September	P and PP	121923·66	121923·66	—
	Q „ D	24·81	24·81	—
	A „ B	23·20	23·20	121923·20
	C „ D	23·20	23 20	23·20
	E „ F	23·54	23·54	23·54
December 22 and 24, with lengths derived from Cape comparisons in January 1901	P „ PP	25·06	—	—
	Q „ D	25·08	—	—
	A „ B	23·53	23·53	23·53
	C „ D	23·82	—	—
	E „ F	23·17	23·17	23·17
Means	—	121923·91	121923·59	121923·33
Probable error . .	—	± 0·16	± 0·15	± 0·06

The wires A, C and E were of steel.
„ B, D and F „ brass.
„ P and Q „ nickel steel *invar.*
„ PP „ nickel steel having a coefficient of expansion somewhat like that of brass.

The pairs of wires P, PP and Q, D were alone used for measurement of the base, but they were compared with the 400-foot ground standard before and after measurement of each section of the base, with the following results, when corrected to the temperature at which both wires have the same length (Jäderin method), assuming the 400-foot ground standard (S) to be constant in length.

1900	P, PP	Q, D
	mm.	mm.
November 3, 4, 5	$\frac{1}{6}$S. − 3·61	$\frac{1}{6}$S. − 3·94
„ 14, 15, 16	− 3·80	− 3·96
„ 27, 28	− 3·76	− 3·95
December 5	− 3 82	− 4·02
„ 17, 18	− 4·01	− 4·19
„ 22, 24	− 4·28	− 4·35

It will be seen from this and the preceding table that the hard work of base measurement has a tendency to induce molecular change in the wires, and that the wires left at comparative rest give more consistent results for the standard ground base (see column *c* of preceding table). It is also evident that new wires have a tendency to contract.

This latter point will be more evident from the following table of the lengths of the wires at 70° F. at the different epochs when their absolute lengths were determined at the Royal Observatory.

—	A Steel	B Brass	C Steel	D Brass	E Steel	F Brass
	mm.	mm.	mm.	mm.	mm.	mm.
(1) April–May, 1898 .	24383·93	24386·23	24384·36	24386·18	24383·57	24385·94
(2) Oct.–Nov. 1898 .	82·65	85·67	84·17	86·04	82·57	85·42
(3) April–May, 1900 .	82·63	86·01	84·13	86·03	83·12	85·77
(4) Aug.–Sept. 1900 .	82·40	85·73	83·91	85·79	82·81	85·19
(5) Jan. 1901 . .	82·15	85·58	83·71	85·84	82·64	85·02

The wires P, PP and Q were only supplied in 1900.

(1) and (2) were the comparisons made before and after the measures of the Inseza base near Bulawayo, of which I give here no further details, as it does not enter into the great arc of meridian; (3) was an intermediate comparison; (4) and (5) the comparisons of the wires made before and after the measures of the Inseza base.

The length of the 400-foot ground standard was adopted from the mean of the measures with all the wires before and after the base measurement.

The adopted lengths of the measuring wires for each section of the base were the mean length derived from their comparison with the ground standard before and after the measurement of that section.

Each section of the base was measured both forwards and backwards by both wires. The following are the results:—

Section	By Wires P and PP	By Wires Q and D	Discordance
	mm.	mm.	
I. *a* . . .	1,646,525	1,646,530	1 in 329,000
b . . .	4,020,152	4,020,130	„ 163,000
II. . . .	3,144,434	3,144,433	„ 3,100,000
III. *a* . . .	3,530,470	3,530,492	„ 161,000
b . . .	1,595,383	1,595,382	„ 1,600,000
IV. *a* . . .	3,715,304	7,758,926	„ 431,000
b . . .	4,0436,40	—	—
	21,695 908	21,695,893	1 in 1,446,000

The adopted mean length is 21,695,901 mm.
71,181·419 feet.

I have gone into this detail in connection with the measurement of the Gwibi base because it is certainly the least accurate of the base lines that occur on the great arc of meridian.

If we adopt instead of the result of column *a* (table A) that derived in column *c*, which may possibly, for reasons explained, be the more correct, we should obtain a shorter length by about 1 : 200,000; on the whole I am disposed to think that the probable error of the base is not much greater than that.

For measurement of the base lines in the Transvaal and Orange River Colony much better appliances were available. The steel-bar measuring apparatus was transported in all cases to the site of the base, and a 480-foot ground standard was measured before and after the measurement of each section of the base, both with the steel bars and the wires used in measurement of the section.

A large amount of time was devoted at Belfast to the training of the base-measuring staff, determining temperature coefficients of wires, and making experiments and tests of various kinds, so that a most effective working staff was created.

I feel certain it would be true economy in all future large geodetic operations to have a base-measuring staff first well trained, and to measure the bases so soon as the reconnaissance has been completed, and before the angles of the chain are definitively measured.

There have been five base lines measured in the Transvaal and Orange River Colony, of which the results are as follows :—

——	No. of Sections	Total Length. Mètres	Probable Error.
			m.
*Belfast Base	9	18,994·027	± 0·009 = 1 : 2,423,000
Ottoshoop Base	8	17,438·178	·005 1 : 3,487,000
Wepener Base	6	21,655·280	·009 1 : 2,406,000
Kroonstad Base	4	19,787·341	·004 1 : 4,946,000
*Houts River Base	8	33,961·340	·005 1 : 6,792,000

Each section of the base was measured three times.
Those marked * occur on the great arc of meridian.

These probable errors of the total length of the base are derived from the differences of the three independent measures of each section, and include, therefore, the effect of the accidental errors of the measurement with the Jäderin wires, the errors of their comparison with the ground standard base of 480 feet, and the measurement of the ground base with the steel bars; *but they do not include* systematic errors due to imperfect knowledge of the absolute length of the steel bars, which may be 1 : 1,000,000.

The three independent measures of the Belfast base give—

18,994·027 mètres.
·077 „
·066 „

The Houts River base is on the arc of meridian north of Belfast, about 100 miles south of the Limpopo. The following particulars about its measurement may be taken to represent the accuracy that can be attained by the Jäderin method when properly employed.

TABLE A.—*Length of 480-foot Ground Base Determined by Measurement with the Steel Bars.*

Date 1904	Temp. (F.) °	Length of Base mm.
May 25	69	146308·75
„ 26	57	·71
June 2	71	·49
„ 7	59	·58
„ 13	70	·43
„ 18	$59\frac{1}{2}$	·68
„ 20	52	·83
„ 25	75	·59
„ 26	68	·77
„ 27	53	·68

TABLE B.—*Apparent Length of Measuring Wires from Comparison with 480-foot Base.*

Date 1904	Wire 1 mm.	Wire 3 mm.
May 26		24381·31
June 2	24380·74	—
„ 7	·77	—
„ 13	·75	—
„ 18	·76	—
„ 20	·77	—
„ 25	·75	—

The wire 3, used in previous bases, met with an accident on May 27; wire 1 was substituted.

Each section of the base was measured three times, viz., once *forward*, then *backward*, finally *forward*. The results are given below.

The separate lengths derived from each measurement are given below :—

TABLE C.—*Measured Lengths of Sections of the Houts River Base, after correction, from comparison with Standard Base.*

Section		mm.	Section		mm.
		418·1			410·9
I.	$180\,l+$	423·4	V.	$192\,l-$	417·2
		437·0			416·9
		59·6			419·7
II.	$200\,l+$	60·6	VI.	$144\,l+$	411·6
		68·3			410·0
		91·7			864·4
III.	$180\,l+$	85·0	VII.	$177\,l-$	865·1
		87·7			859·2
		13622·7			5330·1
IV.	$220\,l+$		VIII.	$130\,l-$	5332·6
		13621·7			5334·4

where $l=24380·0$mm.

The measurements of the base line on the banks of the Loangwa, in Northern Rhodesia, are not yet definitively reduced. The base itself is 17,400 mètres in length; the difference between the two measures was 49 millimètres.

As full details of all the base lines measured with the Troughton & Simms steel bars are given in Vol. i. of 'The Geodetic Survey of South Africa,' I need not go here into further detail, but merely state that their

For Cape Colony and Natal.

Abstract of Triangular Errors.

Observer	Portion of Chains	No of Δs	Limit of Errors of Triangles									Probable Error of a Single Angle
			$''$ 0·0 to 0·5	$''$ 0·5 to 1·0	$''$ 1·0 to 1·5	$''$ 1·5 to 2·0	$''$ 2·0 to 2·5	$''$ 2·5 to 3·0	$''$ 3·0 to 3·5	$''$ 3·5 to 4·0	$''$ 4·0 to 4·5	
	Troughton & Simms 18-*inch Theodolite.*											
M.	Zwaartkop, Newcastle	19	8	3	4	3	—	—	1	—	—	± $0''.492$
M.	Zwaartkop, Griqualand	15	7	3	3	—	2	—	—	—	—	± 0·394
M.	Natal base extension	30	12	4	7	2	3	2	—	—	—	± 0·502
L.	Griqualand Triangulation	36	14	3	9	6	—	3	1	—	—	± 0·522
		100	41	13	23	11	5	5	2	—	—	± 0·493
	Repsold 10-*inch Theodolite.*											
M.	King William's Town to Port Elizabeth	8	3	3	1	1	—	—	—	—	—	± 0·362
M.	Port Elizabeth base extension	13	8	4	1	—	—	—	—	—	—	± 0·213
M.	Port Elizabeth to Caledon	22	8	7	5	1	—	—	1[1]	—	—	± 0·427[1]
M.	Port Elizabeth to Kimberley	37	18	10	6	3	—	—	—	—	—	± 0·314
M.	Kimberley base extension	25	10	8	6	1	—	—	—	—	—	± 0·324
M.	Hanover to Calvinia	23	11	8	3	1	—	—	—	—	—	± 0·294
P.	Tie Chain N. of Mossel Bay	6	4	2	—	—	—	—	—	—	—	± 0·224
		134	62	42	22	7	—	—	1	—	—	± 0·326
Various	Sir T. Maclear's Δs employed in the geodetic circuit	13	5	2	3	1	1	—	1	—	—	± 0·622

M. = Colonel Morris, R.E. L. = Lieutenant Laffan, R.E. P. = Mr. R. Pillans.

[1] This triangle has one line which crosses an arm of the sea, and its error is obviously abnormal. If this triangle is rejected, the probable error of an observed angle in the arc Port Elizabeth-Caledon becomes + $0''.329$, and the general probable error of an angle observed with the Repsold theodolite becomes ± $0''.306$.

accidental errors of measurement are certainly considerably less than the uncertainty of the determination of the lengths of the bars—which uncertainty is of the order of 1 : 1,000,000.

With regard to the accuracy of triangulation, the probable error of

measurement of the angles of the triangles has been computed from the formula

$$\cdot 6745\sqrt{\frac{\Sigma\Delta^2}{3N}},$$

where $\Sigma\Delta^2$ is the sum of the squares of the triangulation errors, and N is the number of triangles.

For the geodetic survey of the Cape Colony and Natal the preceding table exhibits the limits of error of the triangles in excess or defect of $180^\circ+\epsilon$.

The probable error of a single triangle in Bosman's triangulation is as follows :—

Section I.	$\pm 1''\cdot 41$	Very flat, arid country, sides 3 to 8 miles.
„ II.	$\pm 0''\cdot 92$	„ „ „ „ rather longer sides.
„ III.	$\pm 0''\cdot 66$	Rolling country, longer sides.
„ IV.	$\pm 0''\cdot 42$	

In Mr. Alston's connections of the eastern and western extremities of Bosman's arc with the geodetic survey the probable error of an angle was :—

For the Eastern connection $\pm 0''\cdot 58$
„ „ Western „ $\pm 0''\cdot 57$.

In the arc through Damaraland the distribution of triangular errors is as follows :—

—	Limiting Values of Errors of Triangles								
	″ 0·0 to 0·5	″ 0·5 to 1·0	″ 1·0 to 1·5	″ 1·5 to 2·0	″ 2·0 to 2·5	″ 2·5 to 3·0	″ 3·0 to 3·5	″ 3·5 to 4·0	″ 4·0 to 4·5
No. of Triangles	52	48	34	19	18	17	3	2	1

From the original errors of closure of the 194 separate triangles the probable error of an angle was found to be $\pm 0''\cdot 59$.

In the Transvaal, Orange River Colony, and Rhodesia, so far as the results are before me, the triangular errors and probable errors of a single angle are as follows :—

Abstract of Triangular Errors.

Observers	Portion of Chains	No. of Triangles	Limit of Errors of Triangles					Probable Error of a Single Angle
			″ 0·0 to 0·5	″ 0·5 to 1·0	″ 1·0 to 1·5	″ 1·5 to 2·0	″ 2·0 to 2·5	
G.	Belfast–Natal . .	29	15	8	4	—	2	$\pm 0''\cdot 33$
G.	Belfast–Ottoshoop . .	28	14	9	2	2	1	$\pm 0''\cdot 35$
S.	Pretoria–Cwecweni .	63	25	26	10	2	—	$\pm 0''\cdot 30$
G.	Natal–Kroonstad . .	10	6	4	—	—	—	$\pm 0''\cdot 19$
G.	Kroonstad–Kimberley .	18	10	7	1	—	—	$\pm 0''\cdot 23$
L.	Kimberley–Ottoshoop .	57	19	18	12	7	1	$\pm 0''\cdot 33$
		205	89	72	29	11	4	$\pm 0''\cdot 33$

S. = Mr. Alex. Simms. G. = Captain Gordon, R.E. L. = Captain Leys, R.E.

In Northern Rhodesia Dr. Rubin's results, so far, appear to be of like accuracy with those obtained by Mr. Simms in Southern Rhodesia.

But now with regard to the nine crucial tests given in Diagrams Nos. 1 and 2, Plate III..

If it were possible to measure all the angles of a triangulation without error, and base lines without error, it is clear that if the length of any one base was calculated from any other base as origin through any intervening chain of triangles, we should obtain a length of the base by computation which would agree precisely with that of its measured length. As all human operations are fallible, this agreement never occurs except as a matter of chance; and, as the operation of triangulation is necessarily much less accurate than that of base measurement, the discordance between bases compared through intervening triangles is generally far greater than the probable errors of base measurement.

On this account it is usual to consider the base lines as free from error, and to compute by least squares the corrections applicable to the angles of the triangles which are necessary to bring about an agreement between the measured and computed lengths of all the base lines. Colonel Morris has kindly communicated to me the results of the preliminary computations made for intercomparing the bases measured in Cape Colony, the Transvaal, Orange River Colony, and Natal, with the exception of the Limpopo, or Houts River base, the triangulation connecting which with the Belfast base is not yet completed.

Diagram No. 1.

Comparison of Measured Lengths of Bases with Lengths computed from the Port Elizabeth Base (produced).

Base	Through Chain	Approx. Length of Chain	Approx. Length of Base	Apparent Error of Base	Ratio
		Miles	Feet	Feet	
Zwartland . .	1	500	42,819	−1·37	1 : 31,250
Kimberley . .	2	400	14,760[1]	−0·50	1 : 29,750
" . .	3	600	"	−0·50	1 : 29,750
" . .	1 + 3	1,100	"	−0·94	1 : 15,620
" . .	9	1,150	"	−0·45	1 : 32,650
Natal . . .	4	400	10,800	−0·26	1 : 41,770
Belfast . .	5	700	62,316	−0·98	1 : 63,870
Ottoshoop . .	6	950	57,212	−1·88	1 : 30,380
Kroonstad . .	7	1,050	64,920	−1·92	1 : 33,930
Wepener . .	8	1,200	71,048	−1·28	1 : 55,680

[1] This refers to the base prolonged by triangulation from 6,000 feet, directly measured.

It is very remarkable that these comparisons agree in showing all the other bases are apparently shorter than the Kimberley base, and it seems impossible not to conclude that there is some undiscovered source of error in the Kimberley base, although it is hardly possible that the base itself is really six inches too long, as this comparison would appear to show. It is more likely that the error has been produced by a grazing line or lines in the extension of the base; although the residuals in the angles of the quadrilateral figures by which the base was prolonged show extremely small residuals, for one cannot imagine that the measured part of the base

(6,000 feet) can be $2\frac{1}{2}$ inches in error, seeing that the largest difference between the forward and backward measure of any of its eight sections was only $\frac{3}{100}$ of an inch.

Taking now the Belfast base as standard, and comparing it through various independent circuits with the other bases, we get the following results, which are in much better agreement :—

Diagram No. 1.

Comparison of Measured Lengths of Bases with Lengths computed from Belfast Base.

Base	Through Chain	Approx. Length of Chain	Approx. Length of Base	Approx. Error of Base	Ratio
		Miles	Feet	Feet	
Ottoshoop . .	6 – 5	250	57,212	–0·99	1 : 57,900
Kroonstad . .	7 – 5	350	64,920	–0·90	1 : 72,380
Wepener . .	8 – 5	500	71,048	–0·16	1 : 434,300
Natal . . .	4 – 5	300	10,800	–0·09	1 : 120,600
Port Elizabeth .	5	700	17,058 [1]	+0·27	1 : 63,870
Zwartland . .	1 – 5	1,200	42,819	–0·70	1 : 61,160
" . .	9 – 5 + 3	1,250	"	+0·73	1 : 58,690
Kimberley . .	9 – 5	450	14,760 [1]	–0·22	1 : 66,810
" . .	2 – 5	1,100	"	–0·26	1 : 55,680

[1] These refer to the bases prolonged by triangulation; the measured distances were 6,000 feet on both bases.

But besides the discordances of bases when computed through intervening triangulation from one to another, in order to attain geometrical harmony we must also satisfy the condition that the circuits shall close harmoniously ; that is to say, the terminal point of any side of any triangle in the chain, when computed in any direction through the chain, shall be exactly reproduced in latitude and longitude, and the side in length and azimuth.

The discordances are given in the following tables, illustrated by Diagram 2.

Closure on Lines.

Circuit	Circuit Junction	Approximate Length	Log. Discordance of Side	Ratio
		Miles		
(*a*) 1 + 2	Bruintjes–Hooghte–Kagaberg .	1,100	·0000132	1 in 32,900
1	Bushman's Berg–Elandsberg . .	700	·0000084	1 in 51,450
7	Drakensberg – Salt Lake . . .	650	·0000010	1 in 434,300
(*b*) 5 + 7	Lubisi Xuka . .	1,100	·0000031	1 in 140,000
(*c*) 3 + 4 + 5 + 7	Scholtz Kop–Tarantal Kop . .	1,500	·0000029	1 in 150,000

(*a*) This is equivalent to the closure on Kimberley base through chains 1 + 3 and 2 (Diagram 1).

(*b*) Part of the temporarily adjusted chain for the closure on the Natal base.

(*c*) The temporarily adjusted chains for closure on Kimberley and Natal bases enter into this circuit; otherwise the equation would be equivalent to the closure on the Kimberley base through chains 2 and 9 (Diagram No. 1).

Closure in Latitude, Longitude, and Azimuth.

Circuit 1.

Terminal line: Kliprug–Spionberg II.

	Lat.	Long.	Az.
Right hand–Left-hand Branch	+0″·032	+0″·105	+0″·075

Circuit 2.

Terminal line: Canaryfontein–Elandsberg.

	Lat.	Long.	Az.
Right hand–Left-hand Branch	+0″·028	+0″·050	−4″·229.

In circuits 1 and 2 the errors of closure are those obtained after closure of bases.

Circuit 7.

Closure on Drakensberg–Salt Lake through north, west, south, east.

	Lat.	Long.	Az.
'Geodetic Survey,' Vol. i. *minus*. Computed	+0″·021	+0″·060	−0″·43

Circuit 5+7.

Closure on Xuka-Lubizi through north, west, south.

	Lat.	Long.	Az.
'G. S.' Vol. i.—Computed	+0″·172	+0″·120	−1″·48.

Circuit 3+4+5+7.

Junctions at Scholtz Kop with Tarental Kop.
From Drakensberg ('G. S.' Vol. i.) to Scholtz Kop ('G. S.' Vol. i.)

	Lat.	Long.	Az.
('G. S.' Vol. i.)—Computed	+0″·048	+0″·044	−2″·78
Circuit 3, 4	+0″·266	−0″·076	−1″·30
Circuit 5	+0″·151	+0″·060	−1″05

It will be observed that the chains joining Hopetown and Wepener, Kimberley and Ottoshoop, Ottoshoop and Pretoria and Belfast with the Limpopo or Houts River base, are not yet completed, and therefore these circuits cannot be yet discussed. But enough has been done to show the high character of the work.

We turn now to the geodetic results.

Taking first of all arcs of meridian, and beginning from west to east, we have

The Arc near the Meridian of 19° *E. Long.*

This arc depends in the south on Sir Thomas Maclear's arc, part of which has been re-observed by Colonel Morris and entirely re-reduced to the gridiron system of the 'Geodetic Survey of Cape Colony'; then on Alston's triangulation to the Orange River, then on Bosman's triangulation along the 20th meridian to South Reitfontein, and thence northward to Latitude 22 South, through Damaraland, by the Anglo-German Boundary Commissioners, Laffan, Wittstein, and Doering.

Authority		Longitude	Latitud	Astron. *minus* Geod. Lat.	Astron. *minus* Geod. Azimuth
		° ′	° ′	″	″
Sir T. Maclear :	Cape Point . .	18 29	34 21	−0·04	—
„	Zwartkop (C.C.) .	18 27	34 13	−1·27	—
— Gill :	Royal Observatory	18 29	33 56	+0·48	−5·92
Colonel Morris :	Tygerberg . .	18 35	33 51	+1·98	−3·02
„	Robben Island .	18 23	33 48	+0·75	−7 06
Sir T. Maclear :	Klipfontein (Sector Station) .	18 29	32 41	+7·42	—
„	Heerenlogements Berg . . .	18 35	31 58	−0·57	—
„	Kamies Sector Berg	18 8	30 21	+8·14	+1·09
„	North End (Sector Station) . .	18 33	29 44	+0·12	—
Mr. Bosman :	Upington . .	21 14	28 26	−0·50	—
„	Vet Rivier . .	20 0	26 49	−0·96	−2·49
Col. Laffan : Lt. Wettstein : and Lieut. Doering :	Reitfontein . .	20 2	26 44	+0 60	−2 89
	Gibeon. . .	17 46	25 7	+0·77	−6·73
	Gill's Wald. .	18 47	22 57	−1·12	−4·80
	Oliphants Kloof .	20 5	22 11	+3·02	−4·02
	Epukiro . .	20 57	21 55	−0·12	−3·61

The astronomical amplitude of the extreme stations of the arc is 12° 25′ 18″·39. The geodetic amplitude (Clarke's elements), 12° 25′ 18″·31.

This arc, properly speaking, rests on two base lines, viz., the Zwartland base, measured by Sir Thomas Maclear, and a base of which one of its terminals is the point Gill's Wald, measured by the Anglo-German Boundary Commissioners.

	Mètres.
The length of the latter base, computed through the long chain of intervening triangles from one of the sides of the geodetic circuit, is	= 9457·850
The directly measured length was	.= 9457·440
Difference computed-measured is therefore	.= 0·410
	or = 1 : 23·000

The geodetic amplitude of the arc has, however, been computed solely from the Zwartland base, and it would have been increased by about 0″·5 if the Commissioners' base had been taken into account. There is unmistakable evidence of strong local deviation of the direction of gravity at Klipfontein and Kamies Sector Berg, but, apart from these stations, if we divide the arc into groups we have the following results :—

—	No. of Stations	Mean Latitude	Astron. *minus* Geodetic
		° ′	″
Southern End of Maclear's Arc .	5	34 2	+0 38
Northern „ „ „ .	2	30 51	−0·22
Southern End of Boundary Survey	4	26 31	−0·02
Northern „ „ „	3	22 22	+0·60

The reason why the northern base was not taken rigorously into account in the computations is, that it is desirable in so long an arc to measure at least one other base, say in the neighbourhood of Reitfontein,

and it is only waste of time, therefore, to compute corrections to the chain, which will certainly have to be replaced by others at a later date.

The geodetic amplitude could be greatly strengthened by a direct connection southwards, across the Orange River, between the sides Spitzkopje-Karasberge-Sonnabende Hugel with the sides Naib-Agenys or Agenys-Eitjes of Alston's triangles. We may confidently rely on the scientific spirit of Germany to measure at least another base and increase the number of astronomical stations on this arc.

Arc near the Meridian of 26° E. Longitude.

This arc is at present incomplete, because the triangles connecting Kimberley and Ottoshoop are not yet measured. The geodetic latitudes will depend on two parallel chains of triangulation which unite at the northern part of the arc, and cover about 4° in longitude. The astronomical observations at some of the stations have not yet been reduced, and further astronomical stations are required at the northern end of the arc.

The results, however, are interesting as they stand.

—	Long.	S. Lat.	Astron. *minus* Geod. Lat.	Astron. *minus* Geod. Azimuth
	° ′	° ′	″	″
Cape St. Francis	24 46	34 10	+ 0·84	—
Buffelsfontein[1]	—	—	0·00	0·00
Port Elizabeth	25 37	33 58	− 7·37	−0·90
Coega Kop	25 37	33 46	− 7·90	—
Zuurberg	25 34	33 14	+10·96	—
Drivers Hill	26 42	33 17	+ 1·87	—
Berlin	27 37	32 53	+ 6·80	+0·53
Grassberg	24 29	32 51	+10·74	—
Lubisi	27 30	31 47	Not yet reduced	
Tafelberg	25 10	31 38	+ 0·32	—
Washbank Peak	27 30	31 12	Not yet reduced	
Hanover	24 26	31 4	− 0·01	—
Helvelyn	27 14	30 40	Not yet reduced	
Aasvogel Kop	27 5	30 14	Not yet reduced	
De Put	23 55	30 14	− 0·58	—
S. End Wepener Base	27 1	29 50	Not yet reduced	
N. End Wepener Base	26 59	29 37	Not yet reduced	Not yet reduced
Kimberley	24 43	28 38	− 1·57	+1·07
N. End Ottoshoop Base	25 53	25 33	− 4·45	+2·06

[1] Buffelsfontein is the origin of the latitudes and azimuths of the system. The accuracy of the arc when the connection between Kimberley and Ottoshoop has been completed will be very great, as practically five first-class base lines enter into the control of its geodetic amplitude, as well as an excellent gridiron system. The large local deviations of gravity (—$7\frac{1}{3}''$ near Port Elizabeth and + $10\frac{1}{2}''$ at Zuurberg and Grassberg) tend somewhat to diminish the value of the arc as a measure of the earth's mean curvature.

Great Arc along the 30th Meridian north of the Limpopo.

From the Limpopo northwards to the following triangles a gap exists, not yet filled, and the station Salisbury is taken as the new origin both for latitude and azimuth.

Great Arc along the 30th Meridian south of the Limpopo.

—	Long.		Lat.		Astron. *minus* Geod. Lat.	Astron. *minus* Geod. Azimuth.
	°	′	°	′	″	″
Gweeweni . . .	28	0	31	50	Not yet reduced	Not yet reduced
Umtata . . .	28	45	31	36	+2·98	+0·52
Xuka . . .	28	0	31	18	Not yet reduced	
Bendearg . . .	27	55	31	2	"	−1·37
Umtamvuna . .	29	57	30	44	+1·71	—
Durban . . .	31	0	29	51	+2·19	—
Zwartkop . . .	30	15	29	36	+1·32	—
Salt Lake . . .	30	4	27	55	+6·1	—
Newcastle . . .	29	56	27	46	+1·10	−3·33
Hermitage . .	29	20	27	40	Not yet reduced	
Vierfontein . .	28	40	27	32	"	
Inkwelo . . .	29	50	27	31	"	
Kaalkop . . .	29	5	27	30	"	
Gemsbokberg . .	29	27	27	27	−6·3[1]	—
Johannesburg . .	28	6	26	3	−9·33	−1·14
S. End Belfast Base .	30	2	25	40	−3·50	−2·60
Lange Kloof . .	29	57	25	31	−4·41	—
Mare's Kop . .	30	6	25	30	−2·77	—
N. End Belfast Base .	30	22	25	29	−6·61	—

[1] From this point northwards to the Limpopo the observations have not been completed.

	—	Long.		Lat.		Astron. *minus* Geod. Lat.	Astron. *minus* Geod. Azimuth
		°	′	°	′	″	
Observed by Mr. Simm.	Inugu . .	28	24	20	30	− 0·02	—
	Golati . .	28	36	20	29	+ 1·23	—
	M'Quilembegwe	28	45	20	26	− 3·78	—
	Thabas Inyorka	28	41	20	19	+ 0·09	—
	Tsetsa . .	28	22	20	17	—	+ 1·34
	Bulawayo (Long Pt.) .	28	35	20	9	− 10·16	+ 0·72
	S. End Inseza Base . .	29	9	20	6	− 2 75	—
	N. End Inseza Base . .	29	4	19	57	− 3·52	− 2·61
	Gwelo . .	29	50	19	28	+ 0·98	+ 0 26
	Iron Mine .	30	22	19	19	− 4·37	—
	Zontimba . .	30	13	19	16	− 3 99	—
	Mahamara .	30	17	19	5	− 4·44	—
	Salisbury . .	31	2	17	50	0·00(origin)	0·00
	Marimba . .	30	50	17	47	− 4·68	—
	Muneni . .	30	34	17	30	− 5·43	—
	Baruka . .	30	6	17	19	− 3·17	—
	Umvukwe . .	30	41	17	12	− 7·38	—
	Manyangau or Inyangau .	29	36	16	26	− 9·70	+ 4·76
Observed by Dr. Rubin.	Msambamsou .	30	0	15	53	− 8·05	—
	Kapsuku . .	30	20	15	40	− 6·17	—
	Machachetti .	29	52	14	55	− 2·35	—
	Mkokomo . .	30	36	14	37	—	—

From these meridian arcs the results which appear to come out are :—

1. In the arc along the meridian of 19° east longitude the apparent curvature of the meridian between latitudes 22° and 35° corresponds very closely with that given by Clarke's 'Elements of the Figure of the Earth.'

2. Along the meridian of 26° east longitude, between latitudes $25\frac{1}{2}$° to 34°, there appears to be a tendency for the astronomical amplitude to exceed the geodetic by perhaps $0''\cdot1$ per degree, but the great deviations of the plumb-line when one passes from the neighbourhood of the coast to the great mountain range immediately to the north obscures the conclusion.

3. This tendency seems still more strongly marked on the 30th meridian, both in the arcs to south and north of the Limpopo. But that point will be better determined for the arcs on the 26th and 30th meridian south of the Limpopo when the recently made latitude observations have been reduced, and when the arc north of the Limpopo has been carried to Tanganyika ; and still better when the gap between the Limpopo and the Rhodesian triangles has been filled and the Rhodesian arc can be reduced to the same origin as the rest of the geodetic survey.

It was my earnest hope to be able to announce to this meeting that the actual work of this connection had been begun. Captain Gordon, R.E., with a well-trained party, was in readiness to start under the orders of Colonel Morris, but no persuasions of mine could induce the Chartered Company to grant the necessary funds.

Only 1,600*l.* was required, which must be considered a very small sum, having regard to the scientific importance and practical value of the work.

I must admit that the British South Africa Company is loyally carrying out Mr. Rhodes's promise to me—viz., 'I will see that you get the money to carry this survey to Lake Tanganyika, and when you have got there, if the Transvaal has by that time carried its triangulation to the Limpopo, we will meet them there.'

But now that the principal triangulation of the Transvaal and Orange River Colony is nearly complete, and trained men were ready, almost on the spot, to make the connection, a like opportunity to do it so economically and so well is never likely to recur. I say this in justification of my urging the Company, at a time when money is scarce in South Africa, to undertake this work sooner than Mr. Rhodes had promised it would be done.

I do not propose to discuss a comparison between the astronomical and geodetic longitudes, because the data are as yet somewhat meagre, and it has been as yet impossible to organise a longitude campaign with elimination of personal equation and the final control which can only be attained by comparison of results derived through different lines of intercommunication. It is sufficient to say at present that, so far as they go, the longitudes agree better with Bessel's and the latitudes with Clarke's elements.

It remains to mention the services of those who have carried out the work.

First and foremost comes the name of Colonel Morris. To him, and almost entirely to the work of his own hands and eyes, we owe the observations in Cape Colony and Natal—ten years of strenuous service in the

field and one year in office work, given with a singleness of purpose and a devotion and enthusiasm which are beyond praise. To his foresight is due the fact that no accident happened to mar the progress of the work, and to his tact the fact that he and his party were everywhere welcomed, and no objections were seriously raised to his entrance on farms or claims made for damage to property. The rapid progress and the high efficiency of the work in the Transvaal and Orange River Colony are the result of his great experience and administrative capacity.

The difficulties which must beset an international commissioner in another country than his own were overcome by the patience and tact of Lieut.-Colonel Laffan in the Anglo-German Boundary Survey, and high praise is also due to Lieutenant Doering, the German Commissioner, for his loyal co-operation. Both Commissioners had to carry out the work through a country presenting the greatest difficulties to survey operations. In some places the nearest water to the survey points was forty miles distant, and even then the supply was precarious. In others, heavy clearings of shrub and forest had to be made, and the great distances from points where repairs of waggons, &c., could be executed largely increased the difficulties.

Mr. Alexander Simms rendered most valuable service in Rhodesia, where he directed the field operations and made all the observations south of the Zambesi. During the wet weather transport was impossible, and soon after the rains ceased the natives began to burn the grass—a process that filled the air with such dense smoke that no horizontal angles could be measured. Thus the patience and endurance of the observer were most severely tried, and the greatest credit is due to Mr. Simms for the way that he stuck to his trying work and the excellent results that he secured.

To Dr. Rubin and Mr. McCaw in Northern Rhodesia a very heavy and trying task has fallen. They had to encounter similar, and even greater difficulties than those encountered by Mr. Simms—to train natives in heliograph signalling, a matter of the greatest difficulty, as natives are only willing to take short periods of service, and quit the work almost before they are trained. They have now devised simpler methods, which natives can be readily taught, and which are not liable to failure. In this and many other ways they have shown an infinity of resource in trying and difficult circumstances.

The survey owes much to the services of Mr. Robinson, who has been long at the head of the computing staff, and has raised himself by his energy and talent to that position from that of a computer at the Observatory. Mr. Lowinger has done valuable work in a like capacity.

To these men and their cordial co-operation the success of the geodetic survey is due.

I cannot conclude without an expression of regret that, on account of the present financial depression in South Africa generally, it has been found impossible to commence the topographic survey, of which the country stands so much in need and for which the geodetic survey furnishes so reliable a basis.

I cannot think that this most necessary work, for which all the preliminary arrangements have been made, can now be long delayed, and I venture to hope that the influence of the opinion of this Association may be exercised in the way of directing the attention of Ministers to the wisdom of making an early beginning of the work.


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DIAGRAM NO. 1.

Comparison of Measured Lengths of Bases with Lengths computed from Port Elizabeth Base

Comparison of Measured Lengths of Bases with Lengths computed from Belfast Base

DIAGRAM NO. 2.—CLOSURE OF CIRCUITS.

Closure in Latitude, Longitude and Azimuth

Illustrating Sir David Gill's Paper on the Origin and Progress of Geodetic Survey in South Africa, and of the African Arc of Meridian.

Apioidal Binary Star-systems.

By ALEXANDER W. ROBERTS, *D.Sc., F.R.A.S.*

[Ordered by the General Committee to be printed *in extenso*.]

I. *General Statement.*

DURING the past ten years a notable extension has taken place in the area of variable star research.

The scope of this branch of astronomy is no longer simply the ascertainment of the period and amplitude of variation of such stars as fluctuate regularly in brightness, or even the determination of the form and character of their light-curve. Variable star research goes beyond this into a region of investigation, where it marches with the great subjects of cosmic physics and the evolution of binary systems.

Thus the study of variable stars, or at least the study of a certain type of variable star, includes an inquiry into the conditions of magnitude, movement, and position that underlie such changes in brightness as observation reveals to us.

One of the most important of the recent developments in this direction is that dealing with the orbital elements, dimensions, density, tidal pulsations, and secular changes of that remarkable class of stars which for want of a better name we may call apioidal binary systems.

I propose in the present paper considering how far variable star research has led us in an inquiry of such interest and importance as that just indicated. I shall confine myself exclusively to an exposition of the practical side of the subject. As is well known, there is a wide field of inquiry dealing with the theoretical aspects of the problem. The classical researches of Darwin and Poincaré on the evolution and figure of two rotating masses of matter are the most valuable contribution to our theoretical knowledge in this direction. Indeed, long before observation added its testimony in proof of the existence of such strange systems as egg-shaped or pear-shaped stars, Darwin,[1] from theoretical considerations alone, defined their form and described their life-history, thus becoming the honoured pioneer in this wide field of astronomical discovery. Such intimate relation between theory and observation is happily not rare in the history of scientific progress.

Practical work on the subject of apioidal or prolate binary systems dates only from the close of last century; but to understand the nature and importance of the discoveries which made it possible even to enter upon a practical consideration of the problem it is necessary to go some way back in the history of variable star research.

In 1784 Goodricke of York discovered the variation of the bright star *β Lyræ*. Goodricke was able, from his own carefully made observations, to indicate the principal features of the light-changes of this remarkable star, but he was not able to offer any explanation of the peculiar character of its variation.

In 1858 Argelander published his unrivalled series of observations of *β Lyræ*,[2] deducing from them a light-curve of such surpassing accuracy

[1] Figures of Equilibrium of Rotating Masses of Fluid, *Phil. Trans. R.S.*, vol. clxxviii. pp. 379, 428.

[2] *De Stella β Lyræ variabili, Commentatio altera.*

that it still remains the basis of all refined investigation dealing with the variation of *β Lyræ* and stars of the same peculiar type. But progress for full thirty years more ended here. What conditions of motion or position, what chemical or physical forces, produced the definite changes in brightness described so fully by Goodricke and Argelander remained an unbroken secret.

In 1891 Professor Pickering [1] from spectroscopic observations made at Harvard found *β Lyræ* to be composed of two stars revolving round each other in a period synchronous with the alternations in brightness of the dual system. This discovery was subsequently abundantly confirmed by Lockyer,[2] Belopolsky,[3] Vogel,[4] and Sidgreaves.[5] It proved incontestably that the variation of *β Lyræ* was connected in no indefinite way with the movements round one another of the component stars. The immediate cause of variation might be eclipse, or tidal ebb and flow, or cycles of heat and light waves due to changes in surface pressure. It might be all these and much more, but the primal cause of the star's variation was its duplicity; it varied in brightness because it was a binary system, and this was a discovery of no mean value. It meant an advance from a region of uncertainty and conjecture to one of certainty and pregnant facts.

The discoveries of Pickering and other spectroscopists were further enhanced in value by the detection of new variable stars, both in the northern and southern hemispheres, whose light-changes were almost an exact replica of those of *β Lyræ*.

Up till 1892 *β Lyræ* stood alone, *sui generis*, a class by itself. Its variation, therefore, was regarded as anomalous, and probably due to anomalous causes. When, however, observational research revealed the fact that *β Lyræ*, instead of being the sole representative of a very distinct type of variation, was the prototype of an ever-increasing class of variable stars, the problem of its variation became forthwith an investigation of far-reaching importance and scope.

In 1897 Myers [6] pushed the investigation to its legitimate issue by determining the orbital elements of *β Lyræ* from an examination of its light-curve.

This was followed by a similar investigation of the variation of the northern star *U Pegasi*.[7]

The writer had meantime been following out the same line of research at Lovedale, and a preliminary consideration of the light-fluctuations of certain southern stars, especially that of the close binary system *V Puppis*,[8] indicated the need for more refined methods of observation if the results sought were to have any pretensions to accuracy.

The results sought were the form, figure, size, density of those stars that, from their analogy to *β Lyræ*, were binary systems. In addition to the determination of these more easily ascertained orbital elements there arose out of, and indeed formed part of the investigation, the question of

[1] *Astronomische Nachrichten*, No. 3051.
[2] *Astronomy and Astrophysics*, vol. xiii. p. 575.
[3] *Mélanges Mathématiques et Astronomiques*, tome vii. p. 423.
[4] *Sitzungsberichte*, Berlin, February 8, 1894.
[5] *Monthly Notices* R.A.S., vol. lxiv. p. 168.
[6] *Astrophysical Journal*, vol. vii. p. 1.
[7] *Ibid.*, vol. viii. p. 163.
[8] *Ibid.*, vol. xiii. p. 177.

the revolution in space of the line of apsides, the intricate problem of the influence of eccentricity of orbit on prolateness of figure, and the still more obscure matter of the gradual recession of the component stars from one another. And the datum on which an investigation of this nature and scope depended was a variation never much greater than half a magnitude, an alteration in brightness inappreciable to an untrained eye. If a candle be placed at a distance of 100 yards, and its light estimated, it will at once be averred that no eye or instrument can measure the change in brightness consequent on the candle being shifted one yard nearer the observer. Yet such an apparently inappreciable change in brightness is five times greater than the value on which such a determination as that of the alteration in figure due to eccentricity of orbit depends.

It is evident, therefore, that to arrive at results of any weight or value in the cosmical problem of stellar evolution there must be as premises observations of great refinement.

In 1900 I had constructed by Cooke of York a telescope of a peculiar pattern (a pattern suggested by Sir David Gill), by means of which I was able to obtain observations of far greater accuracy than could be secured by an ordinary telescope. The accuracy attained was such as to warrant entering upon a systematic observation of all southern close binary systems with a view to a definite determination of their form, dimensions, movements, and density.

Four apioidal binary systems are under constant observation at Lovedale, and already over 10,000 observations have been secured of one of the most remarkable of these stars, viz., *RR Centauri*. A preliminary determination of the orbital elements of this star,[1] as well as the densities of the other four, have [2] already been published. It is hoped that in 1906 this inquiry may be extended to northern stars of the close binary type, so that any general consideration of the whole problem may rest on a common method of observation.

II. *Particular Exposition of the Problem.*

If two stars form a binary system there are three ways of arriving at a knowledge of the main facts of figure, motion, mass, and density; but no single method yields a full knowledge of these orbital elements. Each method has its limits, but each is supplementary of the other.

It will make for brevity if we state in order the various values which fix the dimensions, size, and position of any binary system.

1. The period of revolution.
2. The size of the orbit.
3. The eccentricity of the orbit.
4. The position of the orbit in space.
5. The inclination of the orbit.
6. The size and form of the component stars.
7. The mass of the components.
8. The density of the components.
9. The surface brightness of the components.

It is evident that determinations of the value of any of the above elements, made at different dates, will yield evidence of any secular change. Such determinations are of special interest when the eccentricity, distance, figure, and brightness of the component stars are in question.

[1] *Monthly Notices* R.A.S., vol. lxiii. p. 527.
[2] *Astrophysical Journal*, vol. x. p. 308; *Nature*, No. 1663, p. 468.

a. If the two components of a binary system are so far apart that they can be readily discerned in a telescope as two points, or even as an elongated point of light, then visual observations, when carefully made and correctly treated, will yield 1, 3, 4, and 5.

This method of inquiry will not furnish any information regarding 2, 6, 7, 8, and 9 unless the distance of the system is known, as in the case of *α Centauri* and *Sirius,* and then forthwith 2 and 7 are also known.

The relation which exists between the visual observations of wide binary systems and the elements of the system have been set forth by many astronomers. The writer has found the formulæ given by Asaph Hall[1] the most convenient in practice.

It must be remembered that as yet no close binary system has been separated, or even elongated, by any telescope, however powerful. I am not without hope, however, that one day, and that not remote, this may be accomplished, especially in the case of vast systems like *V Puppis.*

b. If the system is bright enough to come within spectroscopic range, as in the case of many wide and close binary systems, then this examination yields 1, 2, 3, and 7. Spectroscopic observations yield no clue to 3, 6, 8, and 9.

The equations connecting line of sight observation with the elements of a binary system have been set forth with great fulness by Lehmann-Filhes.[2] I have found, however, the simpler relations established by Rambaut[3] quite as convenient in practice.

c. If two stars of a close binary system revolve in a plane so situated that they mutually eclipse each other, it is evident that the regular ebb and flow of light thus brought about will be a measure of the brightness, size, position, and figure of the component stars. If, accordingly, we determine from observation the variation of a close binary system we have the means of ascertaining 1, 3, 5, 6, 8, and 9. The relation existing between these elements and the light-curve of an apioidal binary system has been set forth by the writer in a paper recently published in the 'Monthly Notices' of the Royal Astronomical Society.[4]

The value of this method of investigation when available, as against *a* and *b*, is at once evident. We know six elements out of the nine, only 2, 4, and 7 remaining unknown. Indeed, with our present limitations, it is only through the avenue of stellar variation that we can arrive at any knowledge whatever of the size and shape of a star.

We may group the preceding statements in a table, thus :—

1	2	3	4	5	6	7	8	9
A	—	A	A	A	—	—	—	—
B	B	B	—	—	—	B	—	—
C	—	C	—	C	C	—	C	C

It is clear from this table that B and C alone will determine all the elements of an apioidal binary system, with the exception of 4, the position of the line of nodes.

[1] *Astronomical Journal,* No. 324, p. 89.
[2] *Astronomische Nachrichten,* No. 3242.
[3] *Monthly Notices* R.A.S., vol. li. p. 316.
[4] *Ibid.,* vol. lxiii. p. 527.

III. *Particular Stars.*

There are eight systems—four in the northern and four in the southern sky—known with certainty to belong to the apioidal class of variable stars. The light-changes of six of these, all typical stars, have been determined with some accuracy. The six stars are :—

No.	Star	Position 1900					Variation	Period			
		H.	M.	S.	°	′	M. M.	D.	H.	M.	S.
2852	*V Puppis*	7	55	22	− 48	58·4	4·7–5·3	1	10	54	27
3055	*X Carinæ*	8	29	7	− 58	53·2	7·9–8·7	1	1	59	0
5099	*RR Centauri*	14	9	55	− 57	23·3	7·4–7·8	0	14	32	7
6758	*β Lyræ*	18	46	23	+ 33	14·8	3·5–4·6	12	21	59	10
7394	*V Vulpeculæ*	20	32	17	+ 26	15·4	8·2–9·8	75	0	0	0
8598	*U Pegasi*	23	52	53	+ 15	23·9	9·3–9·9	0	8	59	41

The light-curve of each of the above stars is given in the appendix to this paper. During the past two years I have been occupied in carrying out a rigorous investigation of these curves, and it may be of interest to state briefly the results already arrived at. Under the second part of the appendix to this paper the more precise numerical values will be given.

V Puppis (*ch.* 2852).

The variation of this star was discovered by Williams[1] in 1886 and its duplicity by Pickering in 1896.[2] It has been under observation at Lovedale since 1891. An examination of its light-curve indicates a slightly elliptical orbit, but spectroscopic observations do not as yet confirm this.

The component stars, which are apparently equal in size, but slightly unequal in brightness, do not quite touch one another. A gap equal to the tenth part of either of their diameters divides them.

When fission in this very interesting system took place it is impossible to say; but reasoning from the analogy of *β Lyræ*, the birthday of *V Puppis* is but in the yesterdays of astronomical time. Probably 400,000 years is an outside limit for its age as two separate stars.

Both stars are considerably flattened; and there is evidence in the light-curve, of great tidal pulsations due to the slightly eccentric orbit of the system.

Each component of *V Puppis* measures 16,000,000 miles[3] along its greatest diameter; the total mass of the system is equal to 310 suns; the density, however, is only 0·02, that is, the stars are two vast gaseous masses.

X Carinæ (*ch.* 3055).

The variation of this star was discovered at Lovedale twelve years ago. It is too faint to come within spectroscopic range.

The mean light-curve indicates that *X Carinæ* is composed of two stars, almost equal in size and brightness, moving round each other, practically in contact, in an orbit only slightly eccentric.

[1] *Astronomische Nahrichten*, No. 3410.
[2] *Harvard Circular*, No. 21.
[3] *Harvard Annals*, vol. xxviii., pt. 2, p. 177.

The density of the system is only 0·05, that is, the stars, like those that form *V Puppis*, are gaseous masses. There is no definite evidence of great tidal movements.

RR Centauri (*ch.* 5099).

This variable is in some respects the most remarkable star of the apioidal binary type. The two stars forming the system are not merely in contact, they slightly coalesce, thus forming one dumbbell body. As might be expected, the prolateness of figure of both components is much greater than we find in the case of any other star of the same class.

The light-curve, which is very regular, indicates a slightly elliptical orbit.

The density of the system is 0·25, and there is evidence of tidal contraction and expansion.

The variation of *RR Centauri* was discovered at Lovedale in 1894, and during the past four years it has been under constant observation. The Oxford wedge photometer has also been used by the writer in estimating the amplitude of its variation.

β Lyræ (*ch.* 6758).

This is the typical star of the apioidal type. For over a hundred years it has been more or less under constant photometric observation, and of late years the spectroscope has added its tale of information regarding the size and motion of this distant, giant system. All observers—Argelander (1840–1859), Schur (1878–1885), Markwick (1898–1901), Belopolsky (1897)—agree in their testimony that the orbit of *β Lyræ* is slightly eccentric. There is also distinct evidence of a secular change in the position of the orbit in space, but this cannot definitely be attested to before a rigorous inquiry into the character and extent of tidal perturbations has been carried out. One secular drift is, however, beyond doubt, viz., the slow but steady secession of the component stars from one another. This change is so important a matter in the problem of stellar evolution that I may be pardoned stating the facts more fully in the form of a table.

The value of the various periods is obtained from an examination of all available data.

Date	Period from Observations	Computed Distance	Computed Distance in miles
	H. M. M. S.		
1780	12 21 – 9 15·0	1·0000	40,000,000
1800	26 11·9	·0006	40,024,000
1820	36 37·2	·0010	40,039,000
1840	43 29·7	·0012	40,050,000
1860	48 54·2	·0014	40,058,000
1880	54 1·8	·0016	40,065,000
1900	59 9·6	1·0018	40,072,000

During the past hundred years the component stars of *β Lyræ* have receded from one another at least 50,000 miles, a small distance truly in stellar measurement; but then a century is in astronomical reckoning a paltry fraction of time. What would such a recession amount to in 1,000,000 years?

In diameter *β Lyræ* is equal to fifty suns, and in mass sixty-eight. Yet the density is indeed small, being only 0·0003 of that of the Sun.

The component stars though nearly equal in size are very unequal in brightness, one star being two and a half times brighter than the other.

The amount of flattening is equal to that of *V Puppis* and *X Carinæ*. The present seems a suitable opportunity for the statement that no refinement of observation or analysis will distinguish between a prolate spheroid and an egg-shaped body. It would require an accuracy of observation correct to $0^{m}\cdot001$ to reveal the difference between a spheroid of two and an ellipsoid of three unequal axes.

V Vulpeculæ (*ch.* 7394).

This recently discovered variable[1] will probably supply questions of no common interest in connection with the many-sided problem of close binary systems. I have in a recent paper to the Royal Astronomical Society called attention to the remarkable rarity of this star. Its density is only 0·00002, that of the Sun being unity.

If now we take this value and place it alongside the long period of the star, seventy-five days, we are impelled in the direction of assuming that in the case of *V Vulpeculæ* we have two vast nebulous orbs, the protoplasm of worlds in the making, circling round each other in measured motion.

The component stars of this system are nearly in contact, and the prolateness of their figure, evident from the form of the light-curve, also points to a distinctly eccentric orbit.

U Pegasi (*ch.* 8598).

All our valuable observations of this star—and they are exceptionally so—we owe to Pickering.[2] His photometric measures indicate a system in direct contrast with that of *V Vulpeculæ*.

U Pegasi fulfils its period in nine hours ; *V Vulpeculæ* in seventy-five days. The density of the former star is 0·36 ; that of the latter, as we have seen, 0·00002. It would appear that in the case of *U Pegasi* we have a system not materially different from what our Earth and Moon were at the genesis of the latter. The density is probably the same, and the period of *U Pegasi* not much greater than that of the Earth-Moon system at the critical bipartition stage.

There is this difference, however, that in the case of *U Pegasi* the two components are practically equal in size, though distinctly unequal in brightness. The existence of vast *U Pegasid* tides is made evident by the slightly unequal brightness of successive maxima.

IV. *General Conclusions.*

From the foregoing considerations of certain close binary systems it is evident—

(1) That density of all stars of this class is exceedingly small. It will be found that the average density of the six stars dealt with in this paper is 0·13 that of the Sun.

(2) All stars of this type are prolate in figure, the amount of flattening depending roughly on the nearness of the stars to one another.

[1] *British Astronomical Journal,* vol. xv. p. 200.
[2] *Harvard Circular,* No. 23.

(3) The component stars of close binary systems move in almost circular orbits. In no case is the eccentricity of motion greater than 0·1; the average eccentricity of the six stars considered is one fourth of this.

(4) There is evidence of a rhythmical change of figure due to eccentricity of orbit.

(6) There is distinct evidence in the case of *β Lyræ* of a recession between the two component stars. This recession is gradually diminishing in rate.

(7) There is also evidence in the case of *β Lyræ* of a secular change in the direction of the line of apsides.

There are certain general conclusions that arise out of a wider view of the subject. Two of these may be stated.

(1) The study of close binary systems, whether photometric or spectroscopic, is of extreme interest as leading directly to the great cosmic question of the evolution of stellar systems. The only practical mode of dealing with the Earth's probable past is by a searching inquiry into the present of such stars as *β Lyræ* and *V Puppis.*

(2) In order that we may afford to future investigators data by which they may estimate such secular changes as take centuries to unfold, it is laid upon us to secure as full and as accurate a series of observations of all close binary systems as possible.

I think it is often forgotten what we owe to posterity in this respect. The present investigation is, I hope, an attempt to discharge some of that debt.

APPENDIX.

Elements of Apioidal Binary Stars.

—	*V Puppis*	*X Carinæ*	*RR Centauri*	*β Lyræ*	*V Vulpeculæ*	*U Pegasi*
Period of star	$1^d\ 10^h\ 54^m\ 27^s$	$1^d\ 1^h\ 59^m\ 0^s$	$0^d\ 14^h\ 32^m\ 7^s$	$12^d\ 21^h\ 59^m\ 10^s$	75 days	$0^d\ 8^h\ 49^m\ 41^s$
Eccentricity of orbit	0·018	0·020	0·017	0·022	—	0·034
Position of apsidal line	279°	165°	342°	190°	—	295°
Inclination of orbit	74°	84°	58°	83°	—	73°
Size of the orbit (miles)	16,000,000	unknown	unknown	40,000,000	—	unknown
Distance of the stars from one another, the semi-major axis being unity	+ 0·10	0·00	− 0·02	0·00	—	+ 0·07
Prolateness of stars	0·50	0·48	0·78	0·50	—	0·51
Relative size of stars	equal ?	equal ?	equal ?	equal	—	equal
Relative brightness of stars	1 : 0·75	1 : 0·92	1 : 0·79	1 : 0·49	1 : 0·39	1 : 0·67
Density of the system (Sun's density being unity)	0·025	0·050	0·250	0·0003	0·00002	0·36
Mass of the system (Sun's mass being unity)	310	unknown	unknown	64	unknown	unknown


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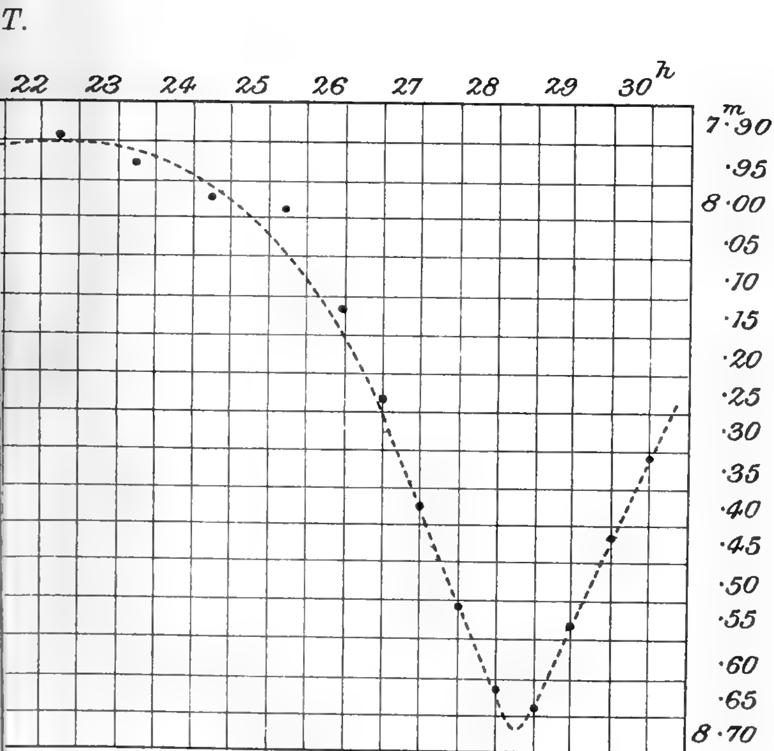
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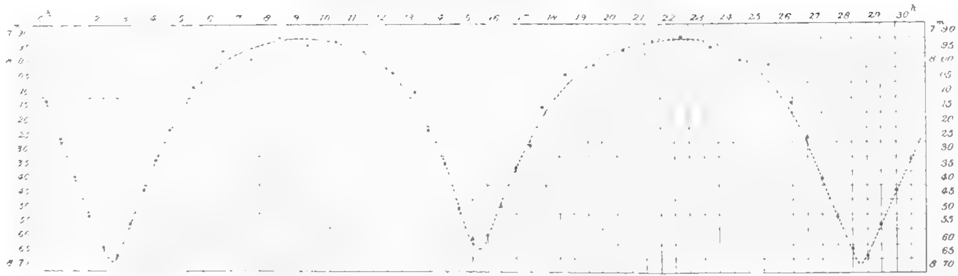

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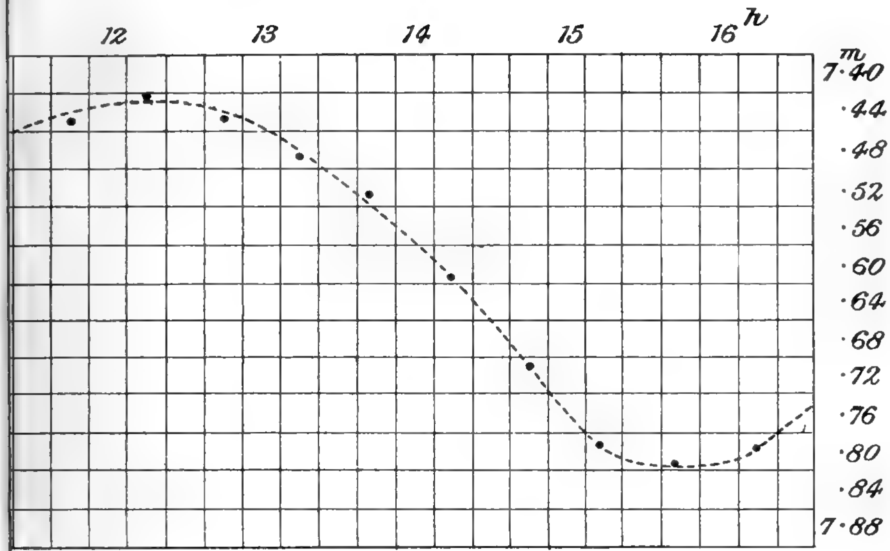
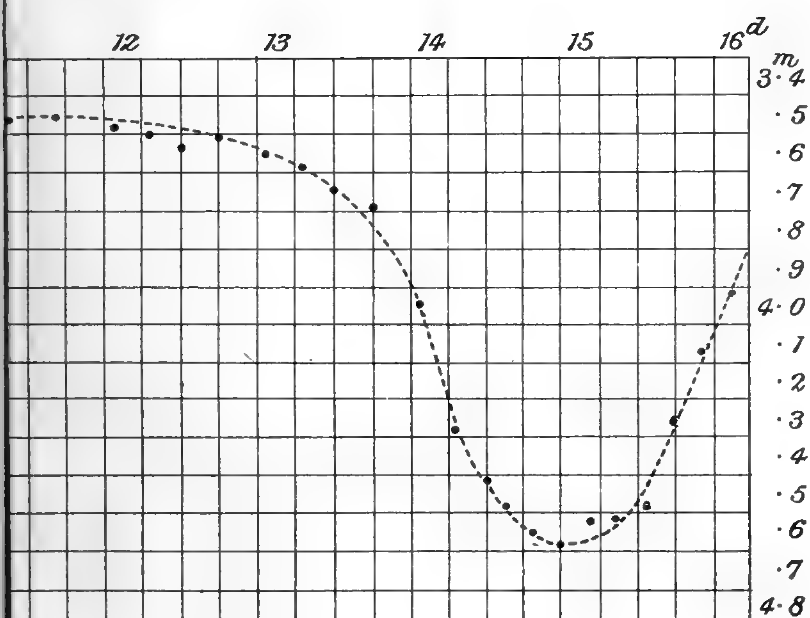
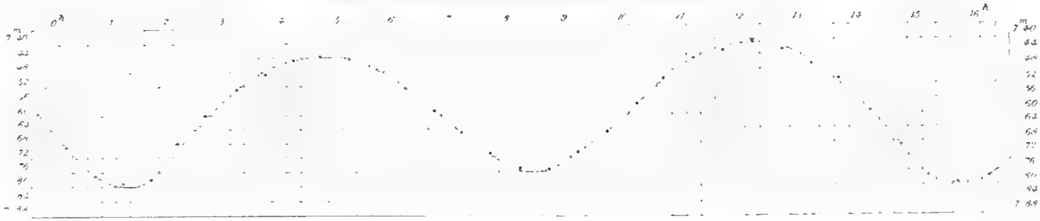
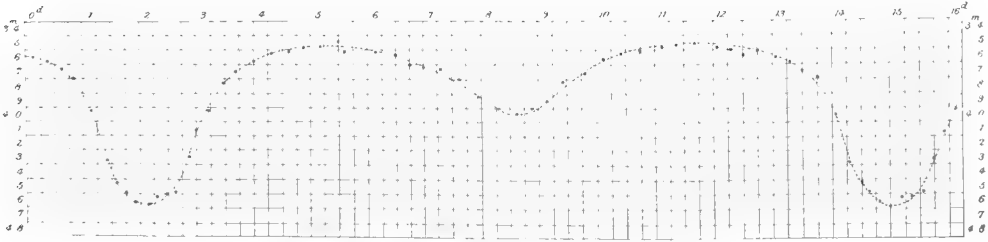


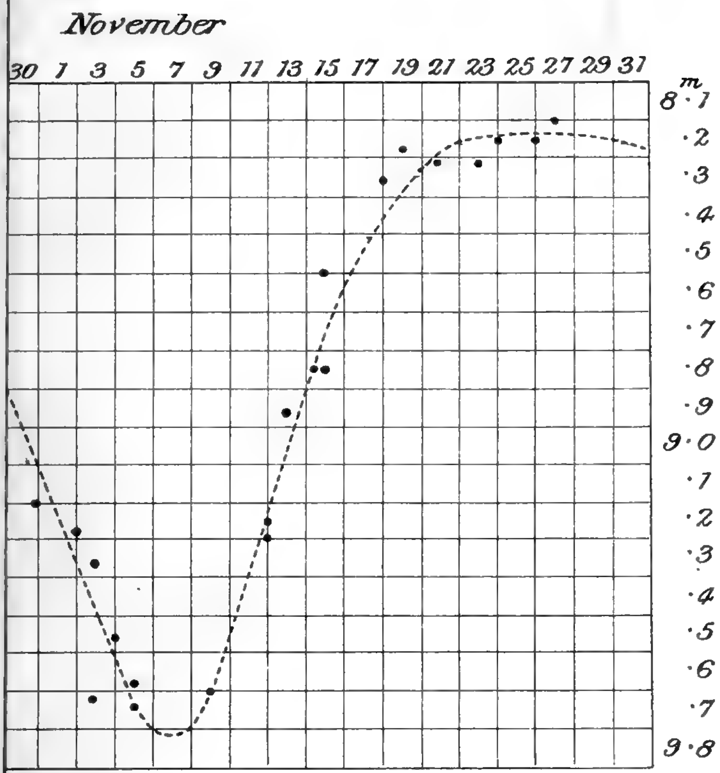


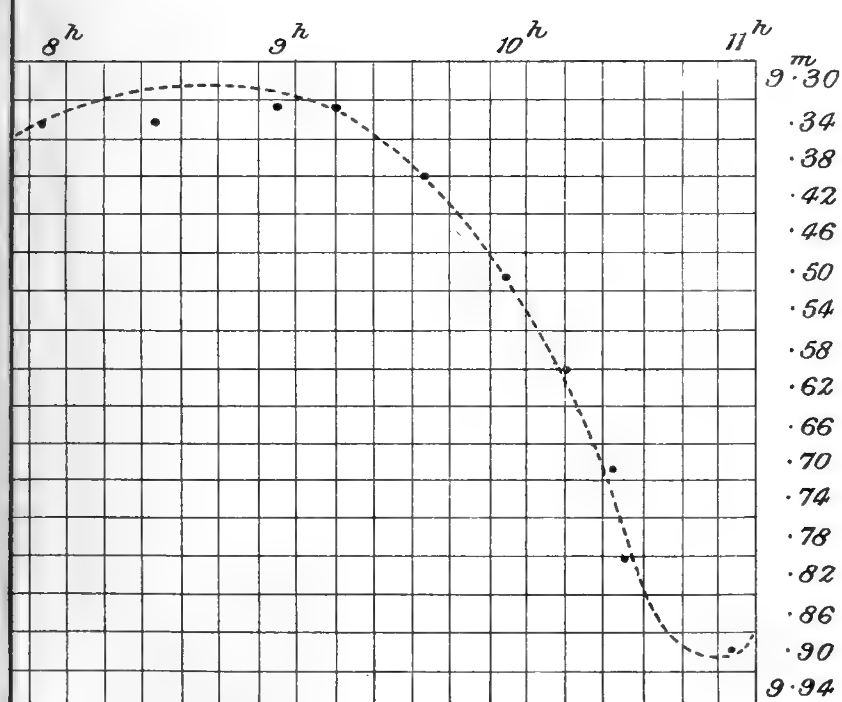
[To follow Diagram 1.





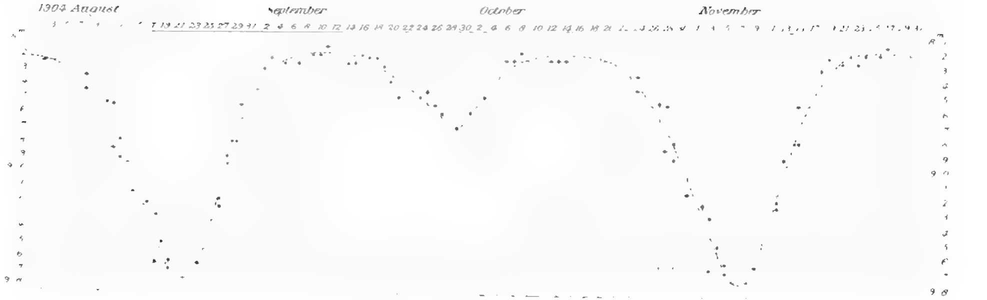
Illustrating Mr. A. W. Roberts' paper on Apsidal Binary Star-systems



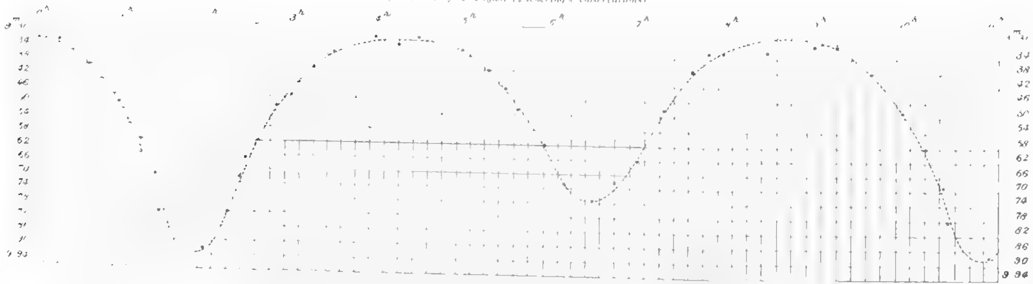


[To follow Diagram 2.

Light Curve of V Vulpeculæ (Stanley Williams' Observations)



Light Curve of U Pegasi (Pickering's Observations)



Illustrating Mr. A. W. Roberts' paper on Apsidal Binary Star systems

Star Streaming. *By* Professor J. C. KAPTEYN.

[Ordered by the General Committee to be printed *in extenso.*]

IN deriving the constant of precession, and in investigating the motion of the sun through space, it is usual to start from the hypothesis that the real motions of the stars, the so-called *peculiar* motions, have no preference for any particular direction.

Of late I have found anomalies in the distribution of the *apparent* proper motions, of so strongly systematic a character that I feel convinced that we are compelled to give up this hypothesis.

It will be the aim of this paper to show the nature of these anomalies, and to explain the conclusion to which they lead us.

It is only just to mention that as early as 1895 Kobold called attention to a fact which seems incompatible with a random distribution of the direction of the motion of the stars. Had Kobold been more successful in separating the systematic motions of the stars from the displacements caused by the sun's motion, he would probably have been led to conclusions similar to those which I am now about to submit to you.

In order to show clearly the anomaly in the distribution of the proper motions here alluded to, it will be necessary to call to mind how this distribution must present itself if the hypothesis of the random orientation of the motions were really satisfied.

For this purpose consider a great number of stars very near each other on the sphere, say all the stars of such a small constellation as the Southern Cross. For convenience' sake we will even assume them to be all apparently situate in the same point S (fig. 1, P) of the sphere, though not in space, because their distance would be different.

The peculiar proper motions of these stars will be distributed somewhat in the manner indicated in fig. 1, P.

In addition to this motion, which represents the real motion of the stars as seen projected on the sphere, they will have an *apparent* motion, the *parallactic* motion, which is due to the observer's own motion, or say the motion of the solar system, through space.

These parallactic motions, we all know, are directed away from the apex, which is the point where the sun's motion prolonged meets the sphere. For *all* the stars at S the parallactic motion will be directed along Sx.

The motions as really observed are the resultant of the peculiar and the parallactic motion.

Thus for the star whose peculiar motion is SB, let Sβ be the parallactic motion, then the *observed* motion of that star will be Sb. Likewise the observed proper motion of the star having the peculiar motion SC will be Sc, and so on.

Making the composition for all the stars of fig. 1, P, we get the really observable motions distributed as in fig. 1, Q.

From this it must be evident that whereas, according to the hypothesis, the distribution of the *peculiar* motions would be radially symmetrical, this symmetry will be destroyed for the *observed* proper motions.

There will be a strong preference for motions directed towards the

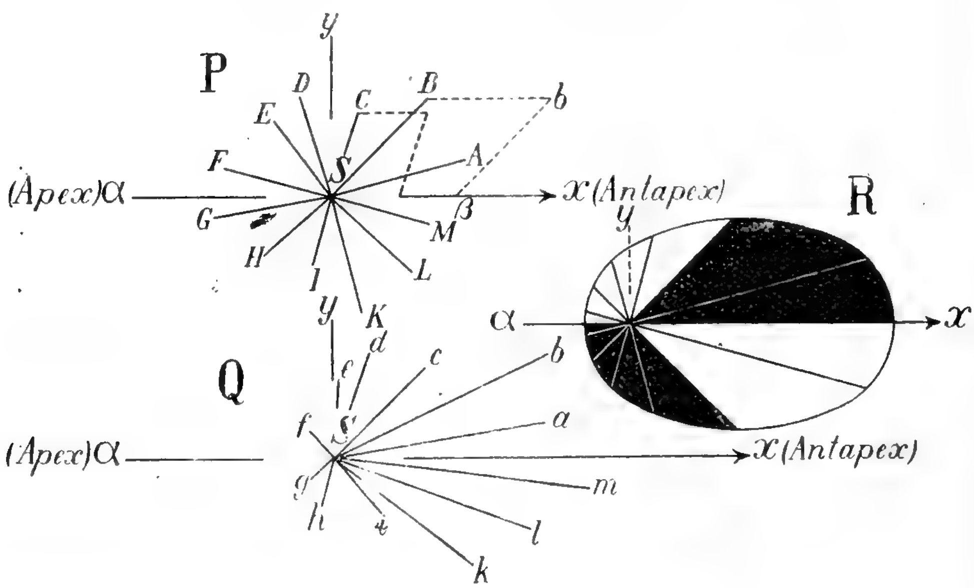
antapex. (See Q.) One thing, however, must be clear, and we want no more for what follows; it is that there will remain a *bilateral symmetry*, the line of symmetry being evidently the line aSx through the apex, the star, and the antapex.

Near to this line, on the antapex side, the proper motions will be most numerous, and they will be greater in amount.

This evident condition of bilateral symmetry would furnish probably the best means of determining the position of the apex. For if from all our data about proper motion we determine these lines of symmetry for several points of the sky and prolong them, they must all intersect in two points, which are no other than the apex and the antapex.

In trying to realise this plan we must meet with the difficulty that on account of errors of observation and the restricted number of stars included in the investigation we must be prepared to find in reality no

FIG. 1



such perfect symmetry as theory demands. For the lines of symmetry we shall thus have to substitute *lines giving the nearest approach to symmetry.* Their position will depend, at least to a certain extent, on what we choose to consider as 'the nearest approach to symmetry.'

If we call the required line of symmetry the axis of the x, the line at right angles thereto the axis of the y, then we may, for instance, define that position of the x-axis as the line of greatest symmetry, which makes *zero* the sum of the y's

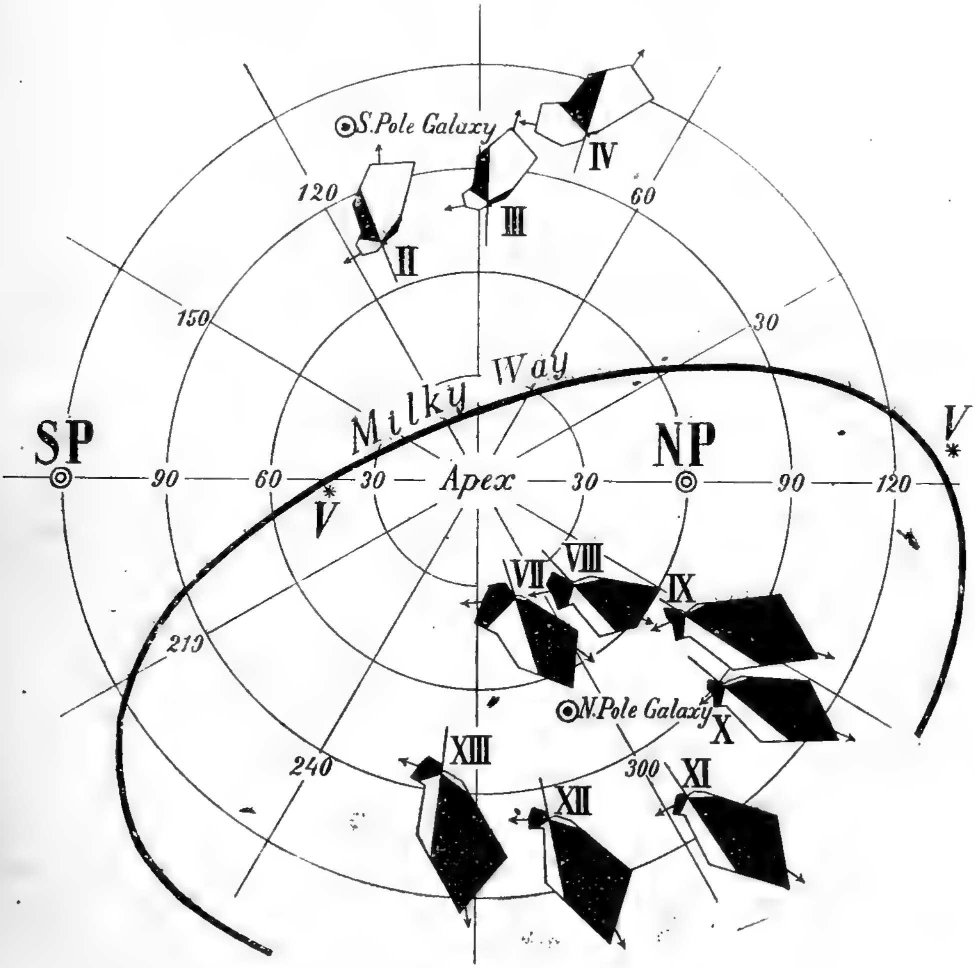
The lines of symmetry furnished by this definition, prolonged, will not pass through a single point; they will all cross a certain more or less extended area, the centre of gravity of which might be taken as the most probable position of the apex.

Drawing great circles through this apex, we must necessarily find them diverging somewhat from the lines of best symmetry in different parts of the sky.

If, however, our hypothesis of random orientation is approximately true, the divergences will be small. The sum of the proper motions at right angles to these circles will be nearly zero in every part of the sky.

Not only that, but we will have further to expect that any other condition of symmetry will be approximately fulfilled, too, for every point

FIG. 2.



Arrows point to the apparent vertices :

A = 85° D = −11°
260° −48°

obtained from direct and retrograde p.m. respectively.

of the sky. Such another condition will be, for instance, that on both sides of the great circles through the apex the total quantity of proper motions shall be the same, or, again, that Σx shall be the same on both sides of these circles.

How the first of these conditions is satisfied is shown in fig. 2. This figure summarises the more important points in regard to the question

in hand. They show in compact form the results of a complete treatment of the proper motions of all the stars observed in both co-ordinates by Bradley (over 2,400 stars). These stars are distributed over two-thirds of the whole of the sky. This surface has been divided up into twenty-eight areas.

From the stars contained on each area I have derived the distribution of the proper motions corresponding to the centre of the area. How this was done need not here be explained. The whole of the materials were thus embodied in twenty-eight figures, like those of fig. 2, each of which shows at a glance the distribution of the proper motions for one particular region of the sky.

Not to overburden the plate I have only included *ten* of the figures, for which the phenomenon to which I wish to draw your attention is most marked.

It is very suggestive that these lie all near to the poles of the Milky Way.

The figures have been constructed as follows: A line has been drawn making the angle of 15° with the great circle through the apex, the length of which represents the sum of all the proper motions making angles of between 0° and 30° with that circle.

In the same way the radius vector of 45° represents the sum of all the motions between 30° and 60°, and so on.

For the sake of uniformity all the results have been reduced to what they would have been had the total number of stars been the same for all the twenty-eight areas.

In order still better to show the important points in the distribution of the p.m. those parts of the figures between the radii vectores making angles of *zero* and $-60°$, $+60°$ and $+180°$ have been blackened.

The position adopted for the apex is practically that found by a variety of methods all more or less akin to that described a moment ago.

If the random-distribution hypothesis were true, and if in consequence thereof the symmetry of our figures were complete, the blackened parts of the figures would have been equal to the corresponding lighter-tinted parts in the way of fig. 1, R.

The real state of things is something quite different, and, what is all-important, we see at once that the divergences are strikingly systematic. The figures at each pole of the Milky Way show them in nearly every particular of the same character. Near the North Pole the blackened parts are invariably much greater; at the South Pole the case is reversed.

At a first glance the difference of the more extensive parts on the side of the antapex is the most striking. As a matter of fact, however, the difference between the smaller parts is by no means less important.

For many of you the way in which the second of the above conditions is satisfied, or rather not satisfied, will be still more convincing.

For each of the twenty-eight regions the mean value of the x component of the proper motions has been computed separately for those lying on the two sides of the great circle through the apex.

If there were real symmetry the two ought to show insignificant differences. The following table shows the value of the difference as really found. Mean values were computed for different galactic latitudes by combining the results of regions at equal distances from the Milky Way:—

—	Mean Centennial Motion		Mean Value of x_R x_L (Centennial Motions)		
Gal. lat. \ Apex: A, D	x_R	x_L	273°·6, +29°·5	291°, +34°	276°, +19°
° °	"	"	"	"	"
−40 to −90	+5·5	+1·3	+4·2	+3·6	+3·2
−20 „ −39	+4·7	+2·5	+2·2	+1·6	+2·4
0 „ −19	+3·1	+1·3	+1·8	+1·2	+1·4
+1 „ +20	+2·3	+2·3	0·0	−1·0	+0·3
+21 „ +40	+2·4	+4·8	−2·4	−2·5	−1·7
+41 „ +90	+2·2	+7·0	−4·8	−3·8	−4·9

This table has been separately derived for stars of Secchi's first and second types, and for those whose spectrum has not yet been determined.

The result has been practically the same for all.

Also the other component of the proper motion at right angles to the former has been investigated. Corresponding divergences are shown.

Finally, in the distribution of the *number* of proper motions over the four quadrants the phenomenon is as evident as it is in our table of the $x_R - x_L$.

About its reality there thus cannot be the slightest doubt.

To what is it to be attributed?

The amount of the divergences summarised in fig. 2 and in our table is so enormous that an explanation of them by an uncertainty of the precession, or about the systematic corrections required by Bradley's observations, is at once excluded. Besides, for both the elements the best available values have been used.

More probable seems an error in the adopted position of the apex. A glance at our fig. 2 may even, perhaps, seem to favour such a view, though a closer examination will show that by displacing this point we shall certainly not succeed in making the phenomenon disappear. To show this more convincingly I have repeated the calculations, on which our table rests, for two other positions of the apex, one differing widely in right ascension, the other in declination. The results are shown in the table. They are practically the same as before.

Or have we to do with a common motion of the whole of the stars which have contributed to any one of our figures?

Such an explanation, too, fails. Systematic motion of this kind will make the lines of symmetry diverge from the great circles through the apex. I therefore investigated what becomes of our results if *for each of our twenty-eight areas* I took for the line of symmetry, *not* the great circle through the apex, but the line which *for every particular area* separately satisfied rigorously the condition $\Sigma y = 0$.

Even with regard to *these* lines the character of the phenomenon is not changed. This proves the inadmissibility of an explanation by local common motion.

As, moreover, in this case the adopted position of the apex acts no part whatever, it proves even more conclusively than the preceding consideration that the phenomenon exists independently of errors in the determination of the apex.

In order to find out what, then, may be the real cause of it I finally set to work as follows :—

I took in hand first the distribution of the *numbers* of the proper motions over the angles of position, counted from the line towards the antapex.

Were the hypothesis of random distribution of the directions satisfied, these numbers, too, ought to show the bilateral symmetry. Only in the apex and the antapex itself, where the parallactic motion disappears, we would still have radial symmetry.

For all the regions at the same distance from the apex and antapex we would expect quite similar figures.

Now since in reality each figure shows anomalies, I made *mean* figures by combining together the data embodied in *all* the figures having the same distance (or rather *sine* of the distance) approximately from the apex and antapex.

So, for instance, were the results of twelve such figures as those of fig. 2, of which the *sine* of the distance from the apex lies between 0·9 and 1·0, summarised in a single set of results.

This mean set proved to be all but perfectly symmetrical, and duly gave the maximum frequency for the direction towards the antapex. For these reasons I felt myself justified provisionally to adopt this set as representing the *normal* distribution for the corresponding distance from the apex; that is, I supposed that this distribution would nearly represent the distribution corresponding to a set of proper motions, really satisfying the random-distribution hypothesis cleared of the inequalities which it is our purpose to find out.

In the possession of this *normal* distribution we now at once obtain these inequalities themselves by simply subtracting the normal numbers from the corresponding ones found directly from the observations for the *individual* regions.

It thus appeared that these inequalities consist in a manifest excess of proper motions in certain determinate angles of position.

These favoured directions have been carefully determined for each of our twenty-eight areas. The greater part of them clearly show *two* favoured directions. For a minority but one of the maxima is well developed.

A careful glance at fig. 2 even shows these maxima already tolerably well.

Entering the two sets of favoured directions on a globe brought out the very striking fact that the directions of each set, separately, converged approximately to a single point. For the one set the approximation is an exceedingly good one; for the other it is only tolerable. A better approximation, however, was not to be expected in this case, because the proper motions on which it rests are far smaller, consequently far less rigorously determined by observation.

The two points lie some 140° apart; the one some 7° south of *α Orionis*, the other a couple of degrees south of *η Sagittarii*.

What this fact means is clear.

When we see that the motions of a certain group of stars converge to a same point on the sphere we conclude either that the real motions of the stars are in reality parallel, or that the motion is only apparent and due to a motion of the observer in the opposite direction. As long as we have no fixed point of reference we cannot decide between the two.

When we see *two* groups of stars converging towards two *different* points the latter explanation fails, at least for one of the groups, because the observer can have but one motion.

From the facts set forth in what precedes we must, therefore, at once conclude that one of our sets must have a real systematic motion in respect to the other.

We can even take one further step. As early as 1843, Bravais has shown, in a paper to which sufficient attention has not been paid, that, no matter how systematic the motions of any group of stars may be, we can determine the motion of the solar system with respect to the centre of gravity of that group. Therefore, if for the present we take the centre of gravity of all the Bradley stars as a fixed point of reference, we can determine the direction of the sun's motion. As far as I know no extensive determination of the solar apex has as yet been made, rigorously on the basis of Bravais' theory.[1] But, for reasons into which we cannot enter here, the result can hardly differ from the best of our modern determinations, made by other methods. This position coincides with neither of the two points found just now.

We thus get a clear indication that we have to do with two star-streams, parallel to the lines joining our solar system to the two points mentioned.

That the method is not rigorous, that, therefore, the directions here found cannot lay claim to any great accuracy, may be left out of consideration for the present. But what is important to note is: (1) that the directions are only apparent directions; that is, directions of the motion relative to the solar system. (2) That if it be true that two directions of motion predominate in the stellar world, then, if we refer all our motions to the centre of gravity of the system, these two main directions of motion must be in reality diametrically opposite. Some reflection must convince you that it must be so, and I will not, therefore, stop to demonstrate it.

For the sake of brevity I will call the points of the sphere towards which the star-streams seem to be directed the *vertices* of the stellar motion.

The *apparent* vertices were thus provisionally found to lie south of α *Orionis* and η *Sagittarii.* Knowing with some approximation the velocity of the sun's motion as compared with the mean velocity of the stars,[2] it is easy to derive from the *apparent* positions of the vertices their *true* positions, which must lie at diametrically opposite points of the sphere.

Having once got what I considered to be the clue to the systematic divergences in the proper motions, and having at the same time obtained an approximation for the position of the vertices, I have made a more rigorous solution of the problem.

I will not here enter into the details of that solution. In order to prevent misconception, however, it will be well to state expressly that the existence of two main stream-lines does not imply that the real motions of the stars are all exclusively directed to either of the two vertices; there is only a decided *preference* for these directions. In my solution I have assumed that the frequency of other directions becomes regularly smaller as the angle with the main stream becomes greater, according to the most simple law of which I could think, which makes the change dependent on a single constant.

I have as yet only finished a first approximation to the solution. The result is that one of the true vertices lies very near to ξ *Orionis*;

[1] Such a determination is now being made by one of my students.

[2] For the mean velocity of the stars see *Astr. Nachr.*, No. 3187.

the other, diametrically opposite, is not near any bright star. They have been represented by the letter V in fig. 2. They lie almost exactly in the central line of the Milky Way. Adopting Gould's co-ordinates of the pole of this belt, I find the galactic latitude to be *two* degrees.

I will pass over the other quantities involved, but will only mention that the way in which I conducted the solution points to the conclusion that *all* the stars, without exception, belong to one of the two streams. To my regret I must pass over also the detailed comparison of theory and observation, because the detailed determination of the distribution of the proper motions from the data of our solution is such a laborious question that I have not yet made it, and would rather defer it till the real existence of the streams shall have been tested by other observations presently to be considered. I will only state that by this provisional solution the *total* amount of dissymmetry for our twenty-eight regions is reduced for the x components as well as for the y components to about *a third* of their amount in the hypothesis of random distribution of the directions. Moreover, they have lost their systematic character.

The observations alluded to as a test of the theory are those of the radial velocities.

I suspect that the materials for a crucial test of the whole theory by means of these radial velocities are even now on hand in the ledgers of American astronomers—alas ! not yet in published form.

It is this fact which long restrained me from publishing anything about these systematic motions, which, in the main, have been known to me for three years.

If I do not hesitate to publish them now it is in the hope of eliciting such spectroscopic data, without which a further development of the theory had perhaps better come to a standstill.

If these spectroscopic observations confirm the theory we may safely go on. If they do not, they will undoubtedly help to find the true explanation of the dissymmetries summarised in such figures as those of fig. 2 and in our table, the real existence of which is demonstrated beyond a doubt.

Further labour devoted to a false theory would be thrown away.

In the meanwhile it seems well worth the trouble to see what evidence can already be got on the question even from the scanty materials which have become public property.

Unfortunately we here meet with some difficulties, which singularly diminish the value of any conclusions that might otherwise still have considerable weight.

First, we have to exclude a relatively large number, which, probably or certainly, do not give a fair idea of the whole. As such I consider the stars only observed because of their excessive astronomical proper motion, or selected from a larger list on account of exceptionally large velocity.

Further, exclude the *Orion* stars which seem to be nearly at rest in space ; their relation to the system must be somewhat exceptional. There remain 78 stars. I have added 46 spectroscopic binaries, though the true velocity of their centres of gravity has been determined only in a few cases. I was mostly compelled to adopt as such the mean of the greatest and smallest of observed velocities.

Small though the collection be, it still offers one formidable difficulty.

Great part of it belongs to the very brightest stars in the sky. For these Campbell has discovered the extremely important fact that they have smaller motions than the mean of the fainter stars.

What may be the cause?

Light will be thrown thereon if more ample data confirm what I found from my scanty store, apparently even more decisively than Campbell's phenomenon, viz., that these stars also lead to a very small velocity of the solar system.

For this would make us conclude that the stars nearest to the solar system partly participate in its motion. The conclusion is strengthened by various considerations, into which time does not allow me to enter now.

On the other hand there were very serious, though perhaps not insuperable, objections which would rather make us seek an explanation in quite another quarter, and which at least compel us to wait for further information.

But, whatever may be the cause of the phenomenon, whether it be cosmical or even only instrumental, we must expect that the spectroscopic observations of the bright stars will show the phenomenon of the star-streams *less strongly* than will the observations of fainter stars; and as our list is made up in great part of such bright objects we must expect to find their influence show in a somewhat less marked degree than we would be led to imagine from the considerations of this paper, which are based on the whole of the stars down to the *ninth* magnitude.

Now this is just what we find to be the case.

I find, arranging in order of the distances from the nearest of the vertices:—

—	Real velocity in the line of sight			
Mean distance from nearest vertex	Obs. veloc.	Number of stars	Theor.	0·827 × Theor.
°				
31	17·37	(49)	21·75	17·99
59	13·78	(30)	15·98	13·22
79	11·16	(45)	13·15	10·87
Mean	14·25	(124)	17·23	14·25
Amplitude	6·21	—	8·60	—

The phenomenon is clearly shown. The observed numbers, however, are only nearly 83 per cent. and the observed amplitude but 72 per cent. of the theoretical value.

A small but independent contribution is furnished by *nine* stars of which the radial velocity has been published on account of its unusually large amount. If our theory is correct the largest radial motions must be far more numerous near the vertices than at a greater distance. The nine stars in question are more thickly crowded (if such a word may be used of so small a number) within 43 degrees from the vertices than in the rest of the sky in the proportion of *three* to *one*.

Taking the evidence for what it is worth, we may say that it confirms the theory. The proof is not convincing, however, and I will conclude by giving expression to my hopes that those who are in a position to test the whole theory by more extensive and more reliable materials will not neglect to do so.

A few hundreds of stars, not pertaining to the *Orion* stars, and fainter than magnitude 3·5, must probably be sufficient for the purpose.

Recent Developments in Agricultural Science.
By A. D. Hall, *M.A.*

[Ordered by the General Committee to be printed *in extenso.*]

In dealing with the science applied to a particular industry like agriculture it is convenient to draw a distinction between the class of investigations which seem to be contributions to knowledge pure and simple and those which aim at an immediate bearing upon practice. Both must be regarded as equally 'pure' science, since both should call for the same qualities of imagination and exact reasoning which characterise true scientific work; but while the one may appeal readily to the intelligent practical man, the value of the other can only be appreciated by the expert. The dividing line between these two branches of the subject is never a sharp one; indeed the most abstract and remote investigations are always cutting into the region of practice in a wholly unexpected fashion; but still the distinction I have indicated can be readily felt. To take an example—for the proper interpretation of many questions connected with the texture of soils and their behaviour under cultivation—it is necessary to arrive at a clearer understanding than we now possess of the intimate causes which lead the finest particles of material like clay to unite together into floccules, or coagula, under the influence of traces of dissolved salts. Such investigations will touch upon some of the most debatable ground belonging to the theory of solutions and the constitution of matter, and can never be made intelligible to the practical man himself; yet a knowledge of their results may be indispensable to the expert whom he consults about the character or management of his land, however trivial and workaday the actual question may seem.

In any agricultural experiment station worthy of its name, place should be found for investigations of this latter class; unfortunately many such institutions are under the necessity of showing 'results' which immediately appeal to the practical man and may be taken to justify the expenditure of public money; so that it is only by side issues, as it were, and by degrees, as the general public can be brought to trust its scientific men, that such work will be undertaken.

It is not my purpose, however, to deal to-day with this form of abstract research. I rather propose to point out certain lines of work in agricultural science which are now being pursued with increasing vigour, and which, from the very outset, promise to have considerable applications in practical life.

It is in the domain of agricultural bacteriology that perhaps the greatest progress has been recently made, in the main progress in connection with that perennial problem—the sources of the nitrogen of vegetation. From the very beginnings of agricultural chemistry, which we may very well date from the publication of De Saussure's 'Recherches Chimiques sur la Végétation' in 1804, discussion has raged round this point. Liebig, in his famous report to this Association in 1842, regarded the atmosphere as the source of the nitrogen contained in the plant; but in the long controversy that followed, the view finally prevailed that the plant was only able to utilise already combined nitrogen in the soil, so conclusive seemed the experiments conducted by Boussingault and by

Lawes, Gilbert, and Pugh at Rothamsted. But a fresh turn was given to the whole question by the discovery made by Hellriegel and Wilfarth in 1887 that the leguminous plants in virtue of the bacteria living symbiotically in the nodules on their roots were able to fix atmospheric nitrogen. From that time research has been directed towards the problem of utilising and rendering more effective this particular *Bacterium radicicola.* Widely distributed as it is in the soil, it is yet not universally present; heaths and peaty soils, for example, that have never been under cultivation frequently lack it entirely; consequently, it is impossible to obtain a satisfactory growth of leguminous crops, upon which in many cases the possibility of successful reclamation is based, until this class of land has been inoculated with the appropriate organism.

Again, although but one species of bacterium seems to exist, yet several investigators have found that by its continued existence in symbiosis with particular host plants it has acquired a certain amount of racial adaptation, so that, for example, clover will flourish best and assimilate the most nitrogen if it be inoculated with the organism from a previous growth of clover, and not from a pea or a bean plant

The conclusion naturally follows that it may be necessary to inoculate each leguminous crop with its appropriate organism in order to secure a maximum yield. The first practical efforts in this direction did not, however, meet with much success: the cultivations used for inoculation were weak, and, when sown with the seed, in many cases died before infection took place. Even when the formation of nodules followed, yet the assimilation of nitrogen was not great. The question in fact turns upon the degree of 'virulence' possessed by the sub-cultures used for inoculation. It is well known with other bacteria how their specific actions may become entirely modified by growing on particular media, or at a high temperature, and even by long-continued growth under laboratory conditions.

B. radicicola does not develop very freely on the ordinary media used for the cultivation of bacteria, nor can it be made to fix much free nitrogen when removed from the host plant. In particular it is maintained that the medium used, gelatine with an infusion of some leguminous plant, causes the organism to lose, to a very large extent, its power of fixing nitrogen, because it contains so much combined nitrogen. G. T. Moore, for instance, says: 'As a result of numerous trials, however, it has been found that although the bacteria increase most rapidly upon a medium rich in nitrogen, the resulting growth is usually of very much reduced virulence; and when put into the soil these organisms have lost the ability to break up into the minute forms necessary to penetrate the root-hairs. They likewise lose the power of fixing atmospheric nitrogen, which is a property of the nodule-forming bacteria under certain conditions.' Latterly the sub-cultures have been made on media practically free from nitrogen, on agar agar, for example, or on purely inorganic media, supplied, of course, with the carbohydrate, by the combustion of which is to be derived the energy necessary to bring the nitrogen into combination.

In example of the two preparations now being distributed on a commercial scale, the one sent out by Professor Hiltner, of the Bavarian Agricultur-botanische Anstalt, consists of tubes of agar which have to be rubbed up in a nutrient solution containing glucose, a little peptone, and various salts, and this after growth has begun is distributed over the soil or the seeds just before sowing. Moore, of the U.S.A. Department

of Agriculture, finding that the bacterium will resist drying, dips strands of cotton-wool into an active culture medium and then dries them. The cotton-wool is then introduced into a solution containing maltose, potassium phosphate, and magnesium sulphate; in a day or two growth becomes active, and the solution is distributed over soil or seed.

It is too early yet to determine what measure of success has been attained by these inoculations with pure cultures; but in considering the results a sharp distinction must be drawn between their use on old cultivated land, such as we are dealing with in the United Kingdom, and under the conditions which prevail in new countries where the land is often being brought under leguminous crop for the first time. Few of our English fields have not carried a long succession of crops of clover, beans, vetches, and kindred plants; the *Bacterium radicicola* is abundant in the soil; and, however new the leguminous plant that is introduced, infection takes place unfailingly, and nodules appear. It is true that the organism causing nodulation may not belong to the particular racial adaptation most suited to the host plant, and that in consequence an inoculation from a suitable pure culture might prove more effective. Again, it is possible that even a plant like clover, which would be infected at once through the previous growth of the crop, might be made a greater collector of nitrogen through the introduction of a race of bacteria which had acquired an increased virulence; but in either of these cases the most that could be expected from the inoculation would be a gain of 10 per cent. or so in the crop. This great, though limited, measure of success depends upon two things—on obtaining races of *B. radicicola* possessing greater virulence and greater nitrogen-fixing power than the normal race present in the soil, and again on the possibility of establishing this race upon the leguminous crop under ordinary field conditions, when the introduced organisms are subject to the competition both of kindred bacteria and of the enormous bacterial flora of any soil. Up to the present all evidence of greater nodule-forming power and increased virulence of the artificial cultures has been derived from experiments made under laboratory conditions without the concurrence of the mass of soil organisms.

In the other case, however, where new land is being brought under cultivation and leguminous crops are being grown for the first time, there can be no doubt of the great value of inoculation with these pure cultures of the nitrogen-fixing organism. An example is afforded in Egypt, where land that is 'salted,' alkali or 'brak' soil, is being reclaimed by washing out the salt; inoculation may be necessary before a leguminous crop can be started on such new land, though in many cases the Nile water used for irrigation is quite capable of effecting inoculation. The body of evidence brought together by the United States Department of Agriculture is very convincing, and shows in repeated examples that the use of Moore's cultures has enabled farmers to obtain a growth of lucerne and kindred plants, which before had been impossible. In view of the economic importance the lucerne or alfalfa crop is assuming in all semi-arid climates, the financial benefit to the farming community is likely to be great and immediate. And since in the development of South African farming the lucerne crop is likely to become very prominent, both as the most trustworthy of all the fodder crops and as the one which brings about the maximum enrichment of the soil by its growth, the behaviour of the lucerne plant as regards

bacterial infection in South African soils is worthy of most careful investigation. It is necessary to know to what extent nodules are formed when lucerne is planted on new soils in South Africa, as, for example, on freshly broken-up veldt; the condition of the organisms within the nodule should be investigated, so as to ascertain if improvement be possible by inoculation from pure cultures, either imported or prepared *de novo* from lucerne within the country. These and kindred questions connected with the symbiosis of the nitrogen-fixing organism and the leguminous plants must to a large extent be worked out afresh in each country, and South Africa, with its special conditions of soil and climate, cannot take on trust the results arrived at in Europe or America.

I have spoken of the enrichment of the soil due to growing lucerne, caused by the decay of the great root residues containing nitrogen derived from the atmosphere; an enrichment which is quite independent of the amount of similarly combined nitrogen taken away in the successive crops of leafy growth. Some of the Rothamsted experiments show very clearly how great the gain may be. In the first place I will call your attention to the effect of a crop of red clover grown in rotation upon the crops which succeed it, since in the Agdell rotation-field we get a comparison between plots growing red clover once every four years and other plots on which a bare fallow is substituted for the clover.

TABLE I.

Manuring for Swede Crop only	Clover 1894.	Wheat, 1895			Roots, 1896			Barley, 1897		
		After Fallow	After Clover	Increase due to Clover	After Fallow	After Clover	Increase due to Clover	After Fallow	After Clover	Increase due to Clover
	Cwt.	lb.	lb.	Per cent.	Cwt.	Cwt.	Per cent.	lb.	lb.	Per cent.
Mineral Manure . .	59·7	4,220	5,180	+22·7	179·1	244·5	+36·5	2,103	3,991	+89·8
Complete Manure . .	76·7	4,547	5,209	+14·6	379·8	388·8	+2·4	3,595	4,913	+36·7

The table shows that in one particular case, when an extra large crop of clover was grown, notwithstanding the fact that the clover plots yielded between three and four tons per acre of clover hay, yet the wheat crop which followed this growth of clover was 15 per cent. better than the wheat crop following the bare fallow. The swede turnip crop, which followed the wheat, although similarly and heavily manured on both plots, continued to be better where the clover had been grown two years previously; and even the barley, which came next, three years after the clover, showed a decided superiority on the clover land. Thus a clover crop, itself wholly removed from the land, exercised a marked influence for good on at least the three succeeding crops grown under the ordinary conditions of farming. Next we can make a comparison between red clover and lucerne. On some of the Rothamsted plots various leguminous plants have been grown for many years, with indifferent success indeed, because of the well-known reluctance of the land to support such crops except at intervals of four or more years. Eventually the plots on which these indifferent crops had been secured were ploughed up and sown with wheat without any manure. In five years the wheat was thus grown on the residues left in the soil by the previous leguminous crops, and from

the table will be seen the comparative value of these residues in the case of lucerne and red clover.

TABLE II.

Harvest	Grain		Total Produce	
	After Lucerne	After Red Clover	After Lucerne	After Red Clover
	Bushels	Bushels	lb.	lb.
1899	39·3	43·0	8,108	8,505
1900	28·9	19·1	4,554	2,992
1901	27·0	21·4	4,054	3,185
1902	20·1	17·7	3,553	3,023
1903	19·9	16·7	3,035	2,528
Total . .	135·2	117·9	23,304	20,233

As we have previously seen how great the benefit of a single year's growth of red clover may be on the succeeding crops, an idea can be formed from the comparison in the latter table of how much more lucerne may contribute towards building up a fertile soil; a point which was very markedly brought out in the experiments of the late Mr. James Mason.

The question of the fixation of atmospheric nitrogen by bacterial agencies does not, however, end with the organisms living symbiotically on the leguminous plants, for several other organisms have latterly been discovered which possess the power of fixing nitrogen independently, provided they are supplied with the necessary nutriment. Of late attention has been chiefly directed to a conspicuous organism known as *Azotobacter chroococcum*, which may be readily identified in most cultivated soils. The impure cultures (which may be quickly obtained by introducing a trace of soil into a medium containing no nitrogen, but a little phosphate and other nutrient salts, together with one or two per cent. of mannite or other carbohydrate) fix nitrogen with considerable activity; in one case, for example, when working with a Rothamsted soil, as much as 19 mg. of nitrogen were fixed for each gram of mannite employed and partially oxidised. But Beyerinck, the discoverer of the organism, now attributes the nitrogen fixation to certain other organisms which live practically in symbiosis with the *Azotobacter*, and which are present in the impure cultures just referred to. The exact source of the nitrogen fixation may be left a little doubtful; still the main fact remains that from the bacteria present in many soils one or a group may be found capable of effecting rapid and considerable nitrogen fixation if the necessary conditions, chiefly those of carbohydrate supply, are satisfied.

But how is the carbohydrate supply to be obtained? Under the normal conditions of arable land farming there are few possibilities in this direction, the occasional ploughing under of a green crop being the only considerable addition of organic matter, other than manure, which is possible in practice. As a matter of experience the plots at Rothamsted, which have been growing crops without manure continuously for the last fifty years, indicate but little gain of nitrogen from the atmosphere. After a rapid fall in production for the first few years, the yield has become so nearly stationary that any further decline is not as yet discernible amid the fluctuations due to season.

Table III.

Average Amounts of Dry Matter and Nitrogen in Total Produce of Various Crops, grown without Manure at Rothamsted.

—		Dry Matter						Nitrogen
		Averages Over					Whole Period	Whole Period
		10 Years 1852–1861	10 Years 1862–1871	10 Years 1872–1881	10 Years 1882–1891	10 Years 1892–1901		
		lb.	lb.	lb.	lb.	lb.	lb.	lb.
Broadbalk	Wheat .	2,199	1,791	1,346	1,480	1,514	1,666	17·0
Hoos	Barley .	2,352	1,797	1,303	1,229	1,120	1,560	15·3
Agdell	Rotation [1] .	2,321	1,817	1,403	1,644	1,295	1,696	17·6
Park	Hay [2] . .	—	2,082	2,144	2,196	1,421	1,961	33·8

Carted fallow portion. First and second crops.

Table III. shows the average yield during the last five decades of dry matter and of nitrogen from four of the unmanured plots at Rothamsted; it will be seen that the difference in the production during the last as compared with the second period of ten years is no more than would be covered by seasonal variations. In other words, the yield, which, as we learn in other ways, is mainly determined by the amount of available nitrogen, has reached a state of equilibrium when the resources of the soil, the material brought down by the rain, and the nitrogen-fixing agencies taken together are just equal to providing the crop with about 17 lb. of nitrogen per acre per annum in addition to the unknown amounts removed by drainage and in the weeds. The small amount of fixation this indicates and the corresponding low level of production must be set down to the lack of combustible carbohydrate, due to the very complete removal of the various crops from the soil, since the root and stubble left behind after the growth of a cereal crop amount to but a small fraction of the total produce.

In the case of grass-land the conditions are entirely different, especially when we are dealing with wild prairie or forest, where the annual growth of carbohydrate falls back to the soil and is available for such organisms as the *Azotobacter*. At Rothamsted two plots of land which were under arable cultivation twenty-five years ago have been allowed to run wild and acquire a natural vegetation of grasses and weeds, subject to no disturbance beyond the occasional eradication of scrub and bushes. Samples of the soil taken when the land was still under the plough have been preserved, and the comparison of these with new samples drawn during the last year shows enormous accumulations of nitrogen, even when every allowance has been made for certain inevitable errors in sampling the soil (see Table IV.). Of these two fields the Geescroft plots are the more interesting, for though showing the gain of nitrogen is less (45 lb. per acre per annum against 98 lb. on Broadbalk), yet continued observation of the herbage that has sprung upon this field has shown the absence of any leguminous plants. According to a botanical analysis made in 1903 the leguminous plants only constituted 0·4 per cent. of the vegetation (as weighed in the dry state) on the Gees-

croft 'wilderness,' whereas the corresponding plot on Broadbalk contained 25 per cent. Now, with no leguminous plants to act as collectors of nitrogen the considerable gains of combined nitrogen on this Geescroft land must be set down to the work of *Azotobacter* or kindred organisms which get their necessary supply of carbohydrate from the annual fall of the grassy vegetation.

TABLE IV.

Accumulation of Carbon and Nitrogen in Soil of Land allowed to run wild for more than Twenty Years.

—	Per cent. in Dry Soil			
	Carbon		Nitrogen	
	1881–3 [1]	1904	1881–3 [1]	1904
Broadbalk, 1st 9 inches	1·143	1·233	0·1082	0·1450
Broadbalk, 2nd "	0·624	0·703	0·0701	0·0955
Broadbalk, 3rd "	0·461	0·551	0·0581	0·0839
Geescroft, 1st 9 inches	1·111	1·494	0·1081	0 1310
Geescroft, 2nd "	0·600	0·627	0·0739	0·0829
Geescroft, 3rd "	0·447	0·435	0·0597	0·0652

[1] Broadbalk, 1881; Geescroft, 1883.

—	Broadbalk		Geescroft	
	1881	1904	1883	1904
Nitrogen — lb. per acre	5,910	8,110	6,043	6,978
" — Increase per acre, per annum, lb.	—	97·8	—	44·5
Ratio of Carbon to Nitrogen	9·4	7·7	8·9	9·2
Ratio of Carbon to Nitrogen in Increase	—	2·9	—	10·7

The fixation of nitrogen must be an oxidising process, for no other natural reaction is likely to provide the energy necessary to bring the nitrogen into combination. This being so, some light is thrown on the process in nature by an examination of the ratio of carbon to nitrogen in the accumulations referred to above. At starting, the ratio of carbon to nitrogen in the organic matter of the two soils was much the same—a little less than 10 to 1—but the increase of carbon and nitrogen in the Broadbalk field, *i.e.*, the organic matter which has accumulated in the interim, shows a ratio of only 3 to 1, while the corresponding accumulations in Geescroft field show a ratio not far removed from the original of about 11 to 1. In other words, where there has been the greater accumulation of nitrogen on the Broadbalk field, there has been the greater combustion of carbohydrate, so that the accumulation of carbon is actually as well as relatively smaller. Bacteriological tests

seem to show a much greater development of *Azotobacter* with increased powers of fixation in the soil from the Broadbalk than from the Geescroft wilderness; a fact to be correlated with the presence of a fair proportion of carbonate of lime in Broadbalk but not in Geescroft field.

Another example may be drawn from the experiments carried on by the late Mr. James Mason at Eynsham Hall, Oxon. He had large cemented tanks filled with burnt clay mixed with appropriate quantities of calcium carbonate and phosphate and other nutrient salts, but containing no nitrogen. One of these tanks, after inoculation with a trace of ordinary soil, was sown with a mixture of grass-seeds and has carried a weak but purely grassy vegetation ever since. According to a recent analysis the soil of this tank has in fifteen years accumulated 0·029 per cent. of nitrogen in the surface soil and 0·117 per cent. in the second layer—equivalent to about 870 and 350 lb. per acre per annum, the ratio of carbon to nitrogen in the accumulation being about 18 to 1 and 12 to 1 respectively.

Henry has also shown that the shed leaves of many forest trees during their decay may bring about the fixation of nitrogen; and this fact, which again depends on the oxidation of the carbohydrates of the leaf to supply the necessary energy, has been confirmed in the Rothamsted Laboratory, as well as the presence of *Azotobacter* on the decaying leaf.

It is obvious that one of the most interesting fields for the study of these organisms must lie in the virgin lands of a country like South Africa. We all know that virgin soil may on the one hand represent land of almost perpetual fertility; on the other it may constitute wastes of any degree of sterility. What are the conditions under which ensues that accumulation of humus whose nitrogen will become available under cultivation, the 'black soils' famous in every continent? The œcological botanists are working out some of the great climatic conditions, the amount and distribution of rainfall and temperature which are associated with 'steppe' areas of great accumulated fertility, but the bacterial flora which is fundamentally bound up with the problem remains as yet unexplored.

It is possible also that on some of the newer lands this and kindred bacteria are absent because the conditions are not entirely suitable to their development. A. Koch has shown that the presence of calcium carbonate is necessary to the action of *Azotobacter*, and determinations of the power of soils from the various Rothamsted fields to induce fixation confirm his results, the development of the organism in question being feeble when the soil was derived from some of the fields that had escaped the 'chalking' process to which the calcium carbonate of the Rothamsted soils is due.

The value of calcium carbonate in this connection only adds to the many actions which are brought about by the presence of lime in the soil—lime, that is, in the form of calcium carbonate, which will behave as a base towards the acids produced by bacterial activity. The experimental fields at Rothamsted afford a singular opportunity of studying the action of lime, since the soil, a stiff, flinty loam, almost a clay, is naturally devoid of calcium carbonate, though most of the cultivated fields contain now from 2 to 5 per cent. in the surface soil, due to the repeated applications of chalk, which used to be so integral a part of farming practice up to the middle of the nineteenth century. Where this chalking process has been omitted, as is the case in one or two fields, the

whole agricultural character of the field is changed: the soil works so heavily that it is difficult to keep the land under the plough; and as grass land it carries a very different and altogether inferior class of vegetation. On the experimental fields it has been possible to measure the rate at which natural agencies, chiefly the carbonic acid and water in the soil, are removing the calcium carbonate that has been introduced into the surface soil, and it is found to be disappearing from the unmanured plots under arable cultivation at an approximate rate of 1,000 lb. per acre per annum; a rate which is increased by the use of manures like sulphate of ammonia, but diminished by the use of nitrate of soda and of dung. Failing the renewal of the custom of chalking or liming—and its disuse is now very general—the continuous removal of calcium carbonate thus indicated must eventually result in the deterioration of the land to the level of that which has never been chalked at all, and even a state of sterility will ensue if much use is made of acid artificial manures. That many soils containing naturally only a trace of calcium carbonate remain fairly fertile under ordinary farming conditions is due on the one hand to an action of the plant itself, which restores to the soil a large proportion of the bases of the neutral salts upon which it feeds, and partly to the action of certain bacteria in the soil, which ferment organic salts like calcium oxalate existing in plant residues down to the state of carbonate. Were it not for these two agencies restoring bases the soil must naturally lose its neutral reaction, since the process of nitrification is continuously withdrawing some base to combine with the nitric and nitrous acids it sets free.

This varying distribution of calcium carbonate in soils suggests another section of my subject, in which great activity has prevailed of late—the undertaking of a systematic series of soil analyses in any district, with a view to making soil maps that shall be of service to the agriculturist. The Prussian Government have long been executing such a soil survey, and during the last few years a similar project has been pushed forward with great energy in the United States; in France and in Belgium several surveys are in progress, but in the United Kingdom the matter has so far only excited one or two local attempts. While the basis of such work must always be the geological survey of the district, a geological survey in which, however, the thin 'drift' formations are of greater importance than the solid geology, there are certain other items of information required by the farmer which would have to be supplied by the agricultural specialist. In the first place the farmer wants to be told the thickness of the superficial deposits: he requires frequent 'ground profiles,' so that he can construct an imaginary section through the upper 10 feet or so of his ground. To take a concrete example: the chalk in the South of England is very often overlaid by deposits of loam, approaching the nature of brick earth, and the agricultural character of the land, its suitability for some of the special crops, like hops and fruit, which characterise that district, will be wholly different according as the deposit is 3 feet or 10 feet deep. The proximity and, if near the surface, the direction of flow of the ground water are also matters on which there could be given to the farmer information of great importance when questions of drainage or water supply have to be considered. It is necessary also to refine upon the rough classification of the soil and subsoil which alone is possible to the field surveyor, one of whose functions will be to procure typical samples of which the texture and physical

structure can afterwards be worked out in the laboratory. Geological formations are constantly showing lithological changes as one passes along their outcrop either in a vertical sense or in their lateral extension; and these changes are often reflected by corresponding changes in the character of the soil which are of commercial importance.

But while the mechanical analysis of the soil has been of late the basis upon which all soil surveys are constructed, it is of equal importance, at any rate in the older countries under intensive cultivation, to undertake certain chemical determinations, which come to possess a new value when taken in connection with a soil survey. It has been generally demonstrated that an analysis, physical and chemical alike, of the soil of a particular field, taken by itself, possesses but little value. The physical analysis will indicate roughly the character of the soil, but very little better than could have been learnt by walking over the soil and digging in it for five minutes; the chemical analysis will disclose any glaring deficiencies; but, as a rule, the analytical figures will be of a very indecisive character, and will lead to little information of practical value. This is because the productivity of a given piece of land depends upon a large number of agencies, any one of which may be the limiting factor in the crop yield. We may enumerate, for example, temperature and water supply, both determined by the climate, by the natural physical structure of the soil, and by the modifications in its texture induced by cultivation; there are further the aëration and the actual texture of the soil, the initial supply of plant-food of various kinds, and, again, the rate at which this last item is rendered available to the plant by bacterial action or by purely physical agencies. All these factors interact upon one another, to all of them and not merely to the nutrient constituents does Liebig's law of the minimum apply; so that any one may become the limiting factor and alone determine the yield. It is of no use, for example, to increase the phosphoric acid content of a soil, however deficient it may be, if the maximum crop is being grown that is consistent with the water supply, or if the growth of the plant is being limited by insufficient root range caused by bad texture and the lack of aëration in the soil. However much we may refine our methods of analysis, we may take it as certain that we shall never be able to deduce *a priori* the productivity of the soil from a consideration of the *data* supplied by the analysis. The function, then, of soil analysis is not to make absolute deductions from the results, but by a comparison of the unknown soil under examination with other soils already known to interpret the divergences and similarities in the light of previous experience. That a given soil contains $\frac{1}{10}$ per cent. of phosphoric acid or $\frac{1}{50}$ per cent. of the same constituent soluble in a dilute citric-acid solution is in itself meaningless information; but it becomes of great value when we know that the normal soils of that particular type contain less than this proportion of phosphoric acid as a rule, and yet show no particular response to phosphatic manuring.

What, then, the soil analyst can do is to characterise the type, ascertain its normal structure and composition, and correlate its behaviour under cultivation, its suitability for particular crops, and its response to manuring in various directions. Thus an unknown soil may by analysis be allotted to its known type, deviations from the type can be recognised, and conclusions may be drawn as to the connection of these defects.

Valuable as recent developments of soil analysis may have been (and I allude in particular to the improvements in the methods of mechanical analysis which have been worked out in the United States Department of Agriculture, to the many investigations that have been made on the measurement of 'available' plant-food by attack with weak acid solvents, to the determinations of the bacterial activity of the soil) the results they yield can only be truly interpreted when they can be compared with a mass of *data* accumulated by the use of the same methods on known soils.

One of the services, then, which the farmers in every country may very properly expect from the scientific man is such a survey of the principal soil types, affording the necessary *datum* lines by which the comparative richness and poverty of any particular soil may be gauged. In an old settled country like the United Kingdom such a survey would guide the farmer in his selection of manures; in a new country the advantages would be even more apparent, as the areas appropriate to particular crops would be indicated, and settlers would be saved from many expensive attempts to introduce things for which their land was unsuited.

It would also be possible to indicate the measures which should be taken to ameliorate the nature of the poorer soils, for, remote as may now seem the prospects of spending time and labour on bad land in new countries where there is still a choice of good, once the road to improvement is indicated little by little the work will be done. It is hardly realised to what extent the soils in England have been 'made'; the practice of 'chalking,' previously mentioned as having doubled or trebled the value of the Rothamsted land, must have added between 100 tons and 200 tons of chalk per acre to those soils before the end of the eighteenth century, and in other parts of the country marling, claying, incorporation of burnt earth and other lighter material have contributed enormously to render the present degree of fertility possible.

The main facts of the nutrition of the plant have been so long established that it is not always realised how much still remains unknown. It has become a commonplace of the textbooks that the plant needs nitrogen, phosphoric acid, potash, often in excess of the quantities present in a normal soil; so that these substances alone are considered of manurial value, other necessary materials like lime, magnesia, iron, sulphuric acid, and chlorine being practically never lacking under natural conditions. But the function of these substances in the development of particular plants, the manner in which the character of the crop is affected by an excess or a deficit, is still imperfectly apprehended. We realise the dependence of vegetative development upon the supply of nitrogen, and how an excess defers maturity; we are also beginning to gather facts as to the manner in which an overplus of nitrogen causes alterations in the structure of the tissues and variations in composition of the cell contents that result in increased susceptibility to fungoid attack. Again, it is clear that potash takes a fundamental part in the process of assimilation, the production of carbohydrate in all forms being dependent on the supply of potash; but of the manner or the location of the action we have no knowledge. Our ignorance of the function of phosphoric acid is even greater; broadly speaking, it hastens maturity, and is bound up with such final processes in the plant's development as the elaboration of seed. With this we naturally correlate on *a priori* grounds the presence of phosphorus in the nucleo-proteids; but there is no particular

evidence that excess of phosphoric acid leads to increased assimilation of nitrogen.

Some of the barley plots at Rothamsted show this very clearly; where there has been no phosphatic, but a nitrogenous, manuring for the last fifty years, the amount of nitrogen assimilated by the crop is diminished, but the gross production of dry matter is still further diminished. By the addition of phosphoric acid the gross production is increased to a greater degree than the amount of proteid formed is increased, so that the crop shows now a smaller percentage of nitrogen and a lower ratio of nitrogen to phosphoric acid than on the plots which are experiencing phosphoric-acid starvation. In other words, where an excess of nitrogen is available the amount assimilated does not increase *pari passu* with the amount of phosphoric acid which the plant can obtain.

But with these three substances all exact knowledge ceases: magnesia, sulphuric acid, and chlorine are invariable and necessary constituents of all plants, yet their function and their practical effects are still unknown. To take a further example, it was early in the history of agricultural science that silica was discovered to be the chief constituent of the ash of cereals and of a few other plants. Liebig's term of 'silica plants' still survives to show the importance once attached to this body, and the earlier experimenters with manures used soluble silicates with the idea of thereby increasing the stiffness of straw. But further investigations showed that cereals could be brought to maturity without any supply of silica, and that the stiffness of the straw was a physiological matter in no way conditioned by silica. As a consequence this plant constituent has now been disregarded for a long time. But it is idle to suppose that a substance present, for example, to the extent of 60 per cent. or so in the ash of the straw of wheat, has no part to play in the nutrition of the plant. Among the Rothamsted experiments there are fortunately some barley plots which have received soluble silica for many years, and a recent examination of the material grown on these plots begins to cast some light on the function of silica. Its effect upon the plant is in some way parallel to that of phosphoric acid; on the plots which have had no phosphatic manure for more than fifty years an addition of soluble silica increases the crop, increases the proportion of grain, and hastens the maturity in exactly the same fashion as, though to a lesser degree than, an addition of phosphoric acid. The results point to the plant rather than the soil as being the seat of the action; a plant that is being starved of phosphoric acid can economise and make more use of its restricted portion if a quantity of soluble silica be available. There is no possibility of replacing phosphoric acid by silica in the general nutrition of the plant, but the abundance of silica at the disposal of the cereals certainly enables them to diminish their call for phosphoric acid from the soil.

Much in the same direction lie the researches which are being pursued with so much vigour by Loew and his pupils in Japan on the stimulus to assimilation and plant development which is brought about by infinitesimal traces of many metallic salts not usually recognised as being present in plants at all. It has been often recognised that substances which are toxic to the cell in ordinary dilutions may, when the dilution is pushed to an extreme, reach a point at which their action is reversed and begins to stimulate. Probably some of the materials used as fungicides and inhibitors of disease act in this fashion by strengthening the whole constitution of the plant rather than by directly destroying or checking the

growth of the fungus mycelium. The subject is certainly one which promises to yield results of value in practice, and calls for more extended and exact observation.

The importance of research on the particular function of the various constituents of the crop lies in the fact that it is only by the possession of such knowledge we may possibly influence in desired directions the quality of our crops. With the effect of manuring upon the yield of most of our crops we are now familiar, but the question of 'quality,' almost as important as that of yield, forms a more difficult problem. One particular example may be cited, that of wheat, because of late years it has been a subject of investigation in most wheat-producing countries. That quality of wheat which is of special commercial importance is its so-called 'strength,' the capacity of yielding flour of such a consistency in the state of dough as will retain the gases produced in fermentation with the formation of a tall, well-piled loaf. This property of 'strength' is usually found in a hard horny and translucent grain, the soft, mealy-looking wheats being as a rule 'weak.' Again, the strong wheats usually originate from districts like the Hungarian plain, the North-West of America, and South Russia, countries characterised by a typical Continental climate, cold and dry in the winter, with rains in the late spring and early summer, and a gradually increasing dryness and temperature up to the time of harvest. The wheats grown under the opposite conditions of a winter rainfall and a dry summer, as on the Pacific slope of North America, or an evenly distributed rainfall as in England or France, are on the whole weak. The differences in this quality are considerable when measured commercially; for example, in most seasons the best Manitoban wheat will be worth 20 to 25 per cent. more than a corresponding grade of English wheat on the London market. The source of strength lies among the nitrogenous constituents of the wheat flour: it can be measured roughly either by determining the proportion of nitrogen in the flour, or by the old process of washing away the starch and leaving the gluten. Neither process agrees exactly with baking tests, nor do any of the more recent attempts to differentiate the wheat proteids by their solubility in various media, as, for example, the determination of the so-called *gliadin glutenin ratio*. In fact in the present state of our knowledge of the possibilities of identifying and separating the proteids in a pure state, there is little likelihood of being able to make out the subtle differences of chemical composition which result in the varying quality of the wheat proteid mass. For example, the relative strength of different varieties of wheat grown under similar conditions will follow the order in which the wheats are placed by their content in nitrogen; yet if, as at Rothamsted, an increased nitrogen content in the wheat is brought about by excessive nitrogenous manuring, the product is actually considerably weaker than wheat on the other plots grown under more normal conditions. The manuring, while increasing the nitrogenous matter of the wheat, has probably introduced a new factor in the shape of a more prolonged development resulting in the lack of those final changes in the nature of the wheat proteids which make for strength. This seems to be indicated by the fact that on storage this particular abnormal wheat gradually increases in strength up to the normal, though never to the degree that would be indicated by its nitrogen content. But though the chemical methods of estimating the strength of wheat have as yet proved incon-

clusive, some idea of the factors determining this quality has been reached from practical baking tests combined with measurements of the gluten and nitrogen content of the flour. In the first place manuring proves a very small factor; the composition of the grain of wheat is extraordinarily stable and the plant reacts to diversities in nutrition by producing more or less grain rather than by altering its composition. Even under the exceptionally pronounced variations in the manurial conditions of the Rothamsted plots, the composition of the grain fluctuates more with changing seasons than with changed manuring. Within the limits of healthy growth and ripening the date of sowing the wheat has no effect upon the quality of the grain; the same wheat sown at monthly intervals from October to March gave practically identical quality in the grain, and a number of comparisons between autumn and spring sowing led to no definite conclusion. Soil has also a comparatively small effect, though, of course, different soils, by inducing differences in the supply of water to the plants and in the temperature, practically result in differences of climate. The effect of climate is large, whether tested by growing the same variety in different countries or by inducing artificial variations in the climate of wheats grown under experimental conditions. But while the climatic factor proves to be large it is less than was anticipated: an English soft wheat, for example, grown on the Hungarian plain for two seasons has not altered greatly in character nor taken on the characteristic appearances of the wheat of the district. A specially strong wheat from the Canadian North-West, after some considerable fall of strength in the first English crop, has fallen no further after three successive crops, and still retains all the characters of an exceptionally strong wheat, although the yield remains poor from an English standpoint. Other varieties have rapidly and entirely lost their strength when changed to English conditions from America, or Hungary, or Russia; many, however, while showing the effect of climate yet stand apart from the typical English wheats and show no tendency to 'acclimatise' in the sense of acquiring the character of the local varieties. In the whole work the thing which stands up most prominently is the fundamental importance of the 'variety'; each race, each botanical unit as it were, possesses an individuality and yields grain of a characteristic composition; and though climate, soil, season, manuring, are factors producing variation in the composition, they are all small compared with the intrinsic nature of the variety itself. Similar conclusions follow from the work of Wood and his colleagues upon the composition of mangels, and of Collins on the composition of swedes. The proportion of dry matter and sugar in the root, while varying markedly in the individual roots, possesses a typical value for each race; and though season, locality, and to some extent manuring affect the composition, the changes thus induced are not great.

Starting, then, from this point, that variety or race is the chief factor in the composition of a given plant, and that, once the variety is fixed, the other factors, which are more or less under control, such as manuring, soil, and climate, have but minor effects upon the quality, the road to the improvement of the quality of our farm crops lies in the creation of new varieties by breeding. An improved variety is all clear gain to the farmer; climate, season, and to a large extent soil are outside his control; while better manuring and cultivation, however much their cost may be lessened by increased skill, yet involve expenditure and become

unremunerative above a certain point. But an improved variety, without costing any more to grow, may increase the returns by 10 or 20 per cent., in some cases may nearly double them.

As regards the value of selection, Wood shows that the composition of the mangel, which has been selected solely for such external qualities as shape and habit, has remained stationary during the fifty years or so for which we possess any information; while between 1860 and 1890 the sugar beet has had its sugar content raised from an average of 10·9 to 15 per cent. by the steady selection of seed-mothers for their richness. The prospects of breeding new varieties of wheat, and particularly of securing improvements in such qualities as 'strength,' have been enormously improved within the last year or two through the investigations which have followed on the rediscovery of Mendel's law of inheritance. Wheat as a normally self-fertilised plant is particularly suited to the investigation of Mendel's law, and the work of Biffen shows that, with a few possible exceptions, the characters of the parent varieties are inherited strictly in accordance with the expectations derived from a consideration of that law. The great practical importance of this generalisation lies in the fact that it thus becomes possible to pick out with certainty fixed types in the third generation of the hybrids, whereas without the guidance of Mendel's law and working by the old plan of selection, followed by continuous 'rogueing,' it was impossible ever to secure a pure strain unless by chance an individual possessing pure recessive or pure dominant characters had been hit upon from the first.

Biffen's work further indicates that the power of producing a glutinous grain, such as will lead to 'strength' in the flour, is a Mendelian character, following the same laws of inheritance as the bearded or beardless habit or the colour of the grain or chaff. Extreme strength shown in any particular wheat can then be picked out and combined with any other essential qualities, such as the yield and the character of the straw, which distinguish our present varieties of wheat. Of course the inheritance of a quality like strength, which is only relative between different varieties, cannot be traced with the sharpness with which such characters as the long-awned bearded type can be followed; still the variation that is, as it were, superimposed upon the 'strength' or 'weakness' representing the inherited Mendelian character is not sufficient to obliterate the evidence of inheritance according to the law. And, of course, this variation of individual seedlings in the 'strong' section above and below the degree of strength possessed by the parent, *i.e.*, the inherited character, gives the plant-breeder his opportunity of improving such a quality at the same time as he is combining with it the other characteristics that are desired in the new varieties. Biffen's work among the wheat hybrids touches also upon another point of special importance to South African farming, where the incidence of 'rust' forms the greatest obstacle to extensive and successful wheat-growing. The climatological conditions which make for a rust attack have not been worked out, as far as can be judged from the behaviour of English wheats in various seasons, together with the prevailing climates in countries where rust is specially prevalent; a flush of growth in the spring followed by high temperatures will favour the disease, but South Africa, with its great variations in the amount and incidence of the rainfall and with its very different temperatures, affords a very good opportunity for

obtaining information on this point. Returning, however, to the question of variety, it is generally recognised that relative immunity or susceptibility to an attack of yellow rust is characteristic of particular varieties, and Biffen finds that such 'immunity' is a true Mendelian character, recessive and therefore only appearing in the second generation of hybrids between a rusting and a rust-proof parent. It is not correlated with shape or character of the leaf, but is transmitted from one generation to another quite independently, and can therefore be picked out of a desirable parent and combined with other qualities of value in different parents. Here, again, we are dealing with a character that is only relative, for no wheat can be called either absolutely rust-proof or entirely susceptible; the offspring that have inherited immunity will still vary a trifle among themselves in the degree of their resistance to attack, and in this possibility of variation lies the chance of the plant-breeder to improve upon the rust-resisting powers of the varieties we now possess.

The whole work of the plant-breeder is of singular importance in a country like South Africa whose agricultural history is so recent. Our European crops represent the culminating points of a tradition, and are the fruit of the observation and judgment of many generations of practical men working, as a rule, with chance material. The products are eminently suited to European conditions, but, as has been seen so often, they fail comparatively when brought into other climates and soils. It follows, then, that in a new country the work of the acclimatiser is one of the necessary foundations for agriculture, and this involves a careful study of climatology and of the influence that the distribution of rainfall and temperature in various parts of the country has on the character of the crop.

Then the cross-breeder's work begins: acclimatisation alone is hardly likely to yield the ideal plant, but by it are found plants possessing the features, one here and one there, that are desiderated; and starting with this ground material the hybridiser can eventually turn out an individual possessing in a large measure all the qualities that are sought for.

There is little hope that science can do anything wholly new for agriculture; acclimatisation, breeding, and selection have been the mainstay of farming progress since the beginning of time, just as the action of the nitrifying bacteria and of nitrogen fixation by the leguminous plants were instinctively apprehended by the earliest farmers of whom we have any record.

But with increasing knowledge comes more power, and particularly the possibility of accelerating the rate of progress; agricultural improvements in the past have resulted from the gradual and unorganised accretions of the observation and experience of many men, often of many generations, now that we are provided by science with guiding hypotheses and by the organisation of experiment with the means of replacing casual opinions by exact knowledge. Even the properties of the soil and the character of our farm crops and animals—stubborn facts as they are and deeply grounded in the nature of things—ought to become increasingly plastic in our hands.

Habits and Peculiarities of some South African Ticks.

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[Ordered by the General Committee to be printed *in extenso*.]

THE *Ixodidæ*, the family of Acarids to which the name 'ticks' is commonly applied, until recently had little attention from students in any branch of science, but of late its members have begun to share the popularity of other blood-sucking parasites as subjects for close investigation. It is certain that ticks are responsible for the spread of a number of stock diseases, and their study therefore possesses much of the importance characterising the study of mosquitoes since the discoveries that some species are intermediate hosts of the malaria protozoans. Numerous workers all over the world have taken up the study of mosquitoes, but thus far only a few have been attracted to ticks. To my mind, the ticks now present the more profitable field for the student, whether he be interested in the systematic classification of species, in the determination of habits and metamorphoses, in experimental research in regard to their transmission of diseases, or in the development of pathogenic organisms within the body of intermediate hosts. An excellent groundwork for the classification of the species has been made by Professor G. Neumann in his 'Revision de la Famille des Ixodides,' which has been published in several parts by the Zoological Society of France during the last ten years; but very little has thus far been recorded on the internal anatomy of any species, and, so far as I am aware, no one has yet traced the development of a disease organism within the body of a tick as has been so ably done in the somewhat analogous case of malaria organisms in *Anopheles* mosquitoes. Also very little has been recorded in regard to the habits and metamorphoses of any species other than those of the genus *Boophilus*.

Ticks of divers species are a severe pest to farm animals in many districts of Cape Colony, and about seven years ago the writer undertook to trace the life-cycle of the most injurious species, *Amblyomma hebræum*, with the object of obtaining data that would assist in determining the best measures and procedure to effect the suppression of the pest. The investigation revived an old-time supposition that *A. hebræum* was associated with a disease called 'heartwater,' which had practically put a stop to the farming of sheep and angora goats in several south-eastern districts; and, encouraged by his success in elucidating the life-history of the species, the writer began a series of experiments which soon showed conclusively that the tick did actually communicate the disease from sick to susceptible animals. The stimulus of these discoveries has led to the conduct of a large amount of experimental research to determine the connection, if any, between other South African stock diseases and ticks, and during the years that have intervened the American discovery that bovine piroplasmosis (Texas fever, or redwater) is transmitted by a tick has been affirmed, and proof over and over again obtained that canine piroplasmosis (malignant jaundice) and African coast fever are also normally tick-transmitted. No one species of tick has thus far been found to carry any two of the diseases, and, indeed, no two diseases have yet been found to be associated with any one genus. Incidental to or in connection with

the experiments, the habits and life-cycles of a number of species of ticks have been studied. It has been found that the habits are remarkably variable in some respects that have important bearing in the transmission of diseases, and on the choice or application of measures for the suppression of particular species; and therefore it is thought that the following compilation of notes on the habits and peculiarities of the species which have come under notice will not be without value. A discussion of the transmission of the diseases pertains more to the pathological section of this Association than to the zoological, and is reserved for a separate paper. The specific names used throughout these notes, except in treating of the genus *Boophilus*, are based on determinations made by Neumann.

Neumann divided the *Ixodidæ* into two sub-families, *Argasinæ* and *Ixodinæ*. Only two genera of *Argasinæ* are recognised, and representatives of both are found in Cape Colony. *Argas persicus* is a very common pest of fowls. *Argas vespertilionis* has been found a few times in places frequented by bats. *Onithodoros savignyi* var. *cæcus* is reported from several dry districts of the Cape and neighbouring colonies, and *O. talaje* var. *capensis* is found in the nests of penguins on the west coast of the Cape, and also at Tristan de Cunha.

Only *Argas persicus* has been closely studied. It is pre-eminently a pest of fowls, but it also commonly attacks geese, ducks, and turkeys, and has been reported to attack canaries and ostriches and man. By tests it has been determined that it will feed on pigeons, but I have not often found it associated with these birds. Both sexes moult the skin three times before becoming adult, and, as with all other ticks studied, the sexes have not been distinguished until the final moult. The eggs are laid loosely in crevices. The largest number laid at one time by a female under observation was 120. The hexapod larva crawls to a host, affixes itself, and remains attached five days or longer. The body meanwhile distends with blood, and towards the last undergoes a change in form, which gives the larval tick the general appearance of the later stages; before this the resemblance is remote. When fully fed, the larva crawls away and secretes itself in any convenient shelter preparatory to moulting. In all its subsequent stages the tick normally visits its host in darkness, and usually remains only half an hour to two hours; it distends itself with blood in this short time and then retreats to a hiding-place.

One visit suffices for each life-stage until the tick becomes adult, and then it alternates its visits with oviposition. Some specimens under observation were fed six times as adults. Thus, during the life-cycle, there is one feeding by the larva or first stage, one by the second stage, one by the third, and an undetermined number which may be more than six by the fourth or adult stage. The minimum interval between the visits varies with the season. In summer the second stage is ready to feed ten days after the larva quits the host, the third stage after a further period of two weeks, and the fourth after about three weeks more; the adults may feed about once a month at this season. During the cooler half of the year all stages are sluggish, and may not once seek a host. The length of time during which specimens may go entirely without food is remarkable. Adults have survived a year's confinement in cardboard pill-boxes in my office desk, and under more natural conditions they take far longer to starve to death. An infested disused fowl-house has been

under observation for over three years. Larvæ were found in the crevices more than six months after the fowls had been removed, and adults were still present in numbers when the place was last searched, thirty-seven months, I believe, after the last opportunity any of them had to take food. The survivors were much shrivelled, but I believe most of them capable of continuing their fast until warm weather sets in again. The male is as large as the female at the time of the final moult, but does not afterwards increase appreciably in length or breadth, whereas the female increases in these dimensions with her first adult feeding. In their subsequent visits both sexes merely distend to the size attained at the first adult feeding. There is still some uncertainty in regard to the copulatory habits of ticks, so it is mentioned that the sexes of the fowl tick have been only thrice observed in connection. In all three cases the male had his rostrum inserted into the genital pore of the female, and both had fed within a few days.

Only a few observations have been made on the habits of other *Argasinæ*, but it appears that *Onithodoros savignyi* var. *cæcus* and *O. talaje* var. *capensis* both alternate short visits to the host with lengthy resting periods. It is said that a not uncommon prank amongst the labourers on the guano islands of the Cape Coast is for the older residents to annoy new-comers by infesting their sleeping places with *O. capensis* specimens. *O. cæcus* also attacks man. It infests loose soil in the shade of trees and rocks in desert-like tracts, and attaches itself to animals which come there to rest. In some parts it infests native huts; and the sites of villages are said to have been changed because of its presence. It may distend itself with blood in less than half an hour. Unlike *A. persicus*, it will attack its victims in daylight. By experiment it has been found that men, goats, sheep, cattle, dogs, and fowls are all acceptable as hosts. The females alternate feasting with oviposition. At least three moultings of the skin occur before the adult stage is reached, and only one feeding intervenes between moults. The larva takes no food. Soon after hatching it undergoes a moult, and becomes the octopod second-stage tick. Specimens in different stages of life have been kept without food in dry sand for upwards of a year.

Acquired adaptation to the surroundings and to the habits of the usual hosts is most apparent in the structure and habits of *A. persicus* and *O. cæcus*. It seems not improbable that the *Argasinæ* are descendants from forms which remained for days at a time on the host, for witness the lengthy feeding period of the larva of *A. persicus*. Were the larger later stages to remain, they would be in great danger of being found and devoured by the fowls. Again, the larva is plump and rounded until it is time for it to leave the host. Then it becomes flattened horizontally like the mature ticks. Were it to remain rounded, or were the later stages to have this shape, there would be difficulty in finding places in which to hide. All the stages of *O. cæcus* are rounded, and such a shape is as good as any other for hiding in loose ground. Obviously, when this tick is on an animal in a desert place it is in danger of being carried away from localities where it has a chance of again finding a host, and hence the shorter its visit the greater its chance of surviving to come again.

The *Ixodinæ* are also admirably adapted for the life they have to lead. All the species that we have reared moult twice, and the life-cycle is thus divided into three active stages—the larval, nymphal, and adult. The larvæ are all hexapod, and the nymphs and adults octopod. Nor-

mally only one visit to the host is paid in each of the three stages, and the visit is always one of several days' duration, the body meanwhile becoming slowly distended. Some species drop to the ground to pass the quiescent periods preceding the moults, whilst others remain affixed to the skin of the host during one or both of these periods. It is stated in some writings that ticks subsist in part on vegetable matter. I have no doubt that they derive their nutrition exclusively from living animals, despite the protracted periods that they often have to await hosts. Unfed larvæ and nymphs and adults that normally moult off the host will retain their vitality for many months when kept in clean, cork-stoppered bottles: this is a general characteristic. Oviposition occurs only once. It normally takes place in the soil or amongst matted vegetation or rubbish affording concealment on the surface. The process is always a slow one, and occupies from a few days to several months. The eggs number thousands, and the female dies beside them soon after she ceases to oviposit. The larvæ ascend vegetation, or anything extending above them, and come to rest generally at the top of some projection. There they may wait for months before an animal by rubbing against their support arouses them to activity. The nymphs and adults of some species also lie in wait on vegetation, and depend on the passing of an animal to brush them off; but those of some other species hide in the ground and scramble to animals that wander near them. Both sexes attach to the host and take nourishment in all three stages. They appear inseparable as larvæ and nymphs, but are easily distinguished by secondary characters when the adult stage is reached. Mating appears to normally take place on the host, and it is usual to find the male affixed to the skin with his ventrum opposed to the ventrum of the female. The males generally, but not always, seek the females. The sexes are produced in about equal numbers; but the adult male generally remains far longer on the host than the adult female, and hence is apparently the more numerous. The duration of the life-cycle is very indefinite owing to the prolonged periods which may be passed in waiting for hosts. It is also greatly influenced by the temperature. The development, as a rule, is most rapid with the temperature between 90° and 100° F. Most species delight in slightly humid surroundings, but some flourish where others would quickly perish by desiccation.

The genus *Ixodes* is placed first in Neumann's classification of the *Ixodinæ*. The only South African species appears to be *Ixodes pilosus*. This species has been found in grass districts of all the colonies, but is usually uncommon. We have had great difficulty in rearing it, and have only succeeded when we have kept the surroundings in which the specimens were undergoing their metamorphoses excessively humid. The necessary condition is naturally found amongst rank vegetation on ill-drained flat ground and in ravines, and it is on animals frequenting such situations that specimens of the tick are generally found. The species in all of its stages seems a general feeder on warm-blooded animals, and to thrive best on the ox, sheep, and goat. The adult has been taken from the horse, mule, ox, goat, sheep, dog, hog, cat, leopard, bushbuck, and man, and both larvæ and nymphs from the first six and man. All stages are partial to the head, and particularly to the ears, but may be found almost everywhere about the body. For convenience we term the period from the dropping of the female to the hatching of the eggs the 'adult-larva stage,' the period from the dropping of the larva to the appearance of the

nymph the 'larva-nymph stage,' and that from the dropping of the nymph to the appearance of the adult, the 'nymph-adult stage.' In the laboratory the adult-larva stage has ranged from forty-three to ninety-three days (six observations) in summer, and from 222 to 309 days (seven observations) when winter was included. The larva takes $2\frac{3}{4}$ days or longer to feed, the nymph generally four, and the adult female five or six when the two sexes are applied together. Our shortest larva-nymph stage record is twenty-seven days, January 26 to February 22, and our shortest nymph-adult fifty-two days, March 12 to May 3. These records were made at ordinary temperature between the dates given. Under out-of-door conditions the life-cycle must generally extend over a full year. The sexes attach independently, and after about three days the male releases his hold and seeks a mate. It is very common to find the male adhering to his mate when she is one third or more developed, with his rostrum buried in the genital pore; and he may remain thus affixed for days, even should the female become fully engorged and be removed. If forcibly detached, he generally loses no time in regaining the position. The male of the English *Ixodes ricinus* behaves similarly; and the object is conjectured to be coition. It is very unusual to find any of the other South African ticks thus sexually united, but by the examination of many hundreds of pairs the observation has been made once or more on *Argas persicus, Onithodoros savignyi* var. *cæcus, Amblyomma hebræum, Rhipicephalus evertsi,* and *Boophilus decoloratus.*

No species of *Aponomma* has been reared by us. Two species, *A. læve* var. *capensis* and *A. exornatum,* have been collected, the former in the adult stage from a black snake and the latter in the nymph and adult stages from the iguana (*Varanus* sp.).

The genus *Amblyomma* contains three South African species that have come to our notice. The bont tick, *A. hebræum,* has been given the closest attention. This species appears to be able to subsist on any warm-blooded animal. We have fed it, or found it attached in all its stages, on the horse, ass, ox, sheep, goat, dog, ostrich, fowl, antelopes of several species, and man. The ox, however, is its principal host, and the one to which it is best adapted. As larva and nymph it freely attaches to any part of the body; but as the adult it does not commonly attach high on the flanks, along the back, or about the head. Eggs laid in the spring and early summer generally hatch before cold weather, but those laid in late summer and during the winter usually remain unhatched until mid-summer of the following year. The shortest adult-larva stage at ordinary temperatures that we have observed took seventy-six days, and the longest 279 days. The time required for the larva to become distended on the host varies slightly with the kind of animal, and more with the part of the animal, to which the tick is attached, presumably owing to the greater ease with which the blood is drawn at one place than another. The stay is usually about six days, but may be as short as four or as long as twenty. The larva-lymph period in an incubator kept constantly between 90° and 100° F. occupies fifteen days; at ordinary temperatures it has occupied from 23 to 120 days. The nymph commonly takes a little longer to feed than does the larva, but many specimens have taken only four and a quarter days; a few have taken twenty-five to thirty. The nymph adult period is about eighteen days in the incubator; at ordinary temperatures it has ranged from 27 to 160 days. The male takes up a position on an

animal, and may remain many months—even a year. In about five days he is ready to mate, and exhibits his inclination by erecting his body and waving his limbs should a female approach close to him. The female is loth to attach except by a sexually mature male, and she appears not to feed to repletion until fertilised. After finding a mate she takes from six and a half to fifteen days or more to distend herself with blood. *A. hebræum* appears to require a warm, moderately humid climate: it thrives best in veld shaded by high bushes, and quite fails to establish itself in open low grass veld and in the Karroo. Its occurrence in Cape Colony is restricted to the southern and south-eastern districts, where there is a summer rainfall. Shade seems necessary to protect its quiescent stages from desiccation. The eggs are particularly sensitive, and owing to difficulty in maintaining the proper degree of humidity in closed dishes exposed to heat, most of the eggs which we attempted to force in the incubator soon perished.

In our experience it is quite common to find unfed larvæ, nymphs, and adults still alive and vigorous after four to six months' confinement in cork-stoppered tubes. We have records of larvæ and nymphs living eight months and then being fed, and a record of an adult which was alive fourteen months after it had fed as a nymph. The life-cycle must ordinarily occupy a full year or more. This species does not at once desert dead animals, but most of the specimens in all stages, if they have fed only a little, detach and wander away in the course of a few days, and such ticks may live a month or more and then attach to other animals. The nymph and adult rest in the ground when awaiting the host.

A. variegatum is closely allied to *A. hebræum*. It is found in Manicaland (Rhodesia), and is occasionally seen on cattle from Madagascar. We have tried to rear it once only. The eggs took the same time to hatch, and the larvæ and nymphs the same time to feed and moult as those of *A. hebræum* would have taken under the same conditions. Our specimens have come from cattle, horses, and goats. The third species, *A. marmoreum*, is less closely related to *A. hebræum*. Like the other two, it leaves its hosts to moult. It has been collected near Capetown in the winter rainfall area, in the dry Karroo, and in the south-eastern districts; hence it appears much less sensitive to heat and drought than *A. hebræum*. Its choice of hosts, however, is most peculiar, and probably accounts for the comparative rarity of the species. The common host of the adult is the tortoise, and all our specimens have come from this reptile, except a few from snakes of one kind or another. On several occasions we have applied adults to the ox and goat, but the only ones that have bitten have been partly fed ones torn from a tortoise. The larva and nymph are not so particular; both feed readily on the ox and the goat as well as the tortoise. The larva also freely attacks birds of some kinds. A dying quail was once brought to me with its head literally covered with engorged larvæ. A small lizard, confined in a jar with hungry larvæ, was attacked with avidity; but it died twelve days later without any of the parasites having become fully distended. That the adult female can ordinarily feed to repletion on a snake is doubtful. When fully engorged a well-developed female measures 25 mm. to 33 mm. in length, and 20 mm. or more in breadth, and one would almost surely be brushed off or crushed during its growth were the snake to move about very much. But the helpless tortoise is a safe host, and the retraction of the body within the shell may often suffice to protect the ticks from bird

enemies. A female tick, collected September 23, 1903, was kept under observation. Oviposition began about November 25, and the eggs began to hatch January 23. Larvæ fed to repletion on the scrotum of an ox in five days, and on the leg of a goat in six. The larva-nymph stage occupied sixteen days in the incubator. Nymphs fed in from seven to nine days, and the nymph-adult stage took eighty-two days (September 19 to December 10) at the temperature of the room. These figures indicate that the species develops in about the same time as *A. hebræum*. Only five females have been fed to repletion. One came away in sixteen days, one in twenty, two in twenty-seven, and one in forty-five. The males and females attach in the first place without reference one to the other, and we do not know whether the male seeks the female, or the female the male. Both have been found to detach themselves and move about, but whether to find a mate or a better position for feeding is uncertain. Males have moved up to females, and females to males.

No tick has given us more trouble to rear than *Hyalomma ægyptium* var. *impressum.* This species is found throughout South Africa, even in the dryest parts. The adult probably attacks any warm-blooded animal. It is common to find it on the horse, ox, sheep, goat, hare, and ostrich, and it has been taken from the dog, fowl, and man. By choice it attaches about the feet and under parts of the larger animals. The larva has consistently failed to feed time after time when applied to the horse, ox, goat, sheep, dog, and man. Many thousands of vigorous specimens have been placed on one or more goats on at least twenty different occasions, and though a few generally attached to the skin, none ever fed to repletion. Finally the discovery was made that it would feed readily on the head of a fowl or on the head of a rabbit; and now we know it too frequently infests the head of the common hare of the country, and specimens have been taken from the head of several birds, including the ostrich.

It takes about nine days to feed, and remains affixed to the skin whilst it moults to the nymph. The nymph attaches close by the old skin, and becomes fully distended about the twenty-first day (seventeen to twenty-five days); it then drops. The nymph-adult stage has taken seventeen days in the incubator and twenty-eight days or longer in summer at ordinary temperatures. The adult-larva stage has taken forty-two days in the incubator and seventy-one days, from October 15 to December 24, in the only record at ordinary temperature that we have preserved. Unfed larvæ have remained active in a glass tube for nine months. The unfed adult is often seen running about the ground, and has been found in numbers hiding under the bark of a tree at an outspan. The male and female attach to the host independently at first, but get together after a few days. Only a few females have been fed to repletion under observation: two of these came away six days after being applied to a beast on which males had been present for two days. It is not probable that the life-cycle ordinarily occupies less than a year.

The only species of *Hæmaphysalis* we know in South Africa is *H. leachi*, the common dog tick of the country. It is common in the coastal and grass veld districts. The species appears practically confined to carnivora, and very few specimens have been detected on cattle even where it is most common. We have found it on the dog, cat, leopard, jackal, and ox. All stages feed readily on the dog, cat, and jackal, and appear not to be partial to any particular part of the body unless it is to

the neck. Both moults take place off the host. The adult-larva stage has been as short as twenty-nine days at midsummer; and midwinter-laid eggs have hatched within 100 days at the office. The larva and nymph, as a rule, distend and fall after a visit of forty-seven to seventy hours, and the adult female generally remains eight to ten days. The male may remain ten weeks or more. The larva-nymph period may be only ten to twelve days at midsummer, and the nymph-adult period only eighteen days; in the incubator the nymph-adult period has varied from fourteen to eighteen days. The sexes attach independently, and after about three days the males detach and search for mates. The female distends, whether fertilised or not; but the eggs of the few unfertilised ones observed have failed to hatch. The male, at least, is quick to detach from a host that dies. All stages await in some elevated position for some animal to brush them off in passing. Unfed adults have lived over seven months in a tube. There are probably two or three generations in a year under favourable conditions.

Since Neumann wrote his monograph he has decided that the genus *Rhipicephalus* should be divided into two sub-genera, *Eurhipicephalus* and *Boophilus*. *Eurhipicephalus* contains several South African species that resemble one another so closely in their structural characters that it is difficult to distinguish them, especially in the larval and nymphal stages. The specific identity of some forms that we have attempted to study is in doubt. One undetermined species feeds in all its stages on hares, and appears as common in the dry Karroo as in coastal districts. Any discussion of structural characters is avoided in these notes; but, owing to ignorance of the fact being a source of error to systematists, it seems desirable to mention that adult *Rhipicephalus* males, during their stay on the host, change somewhat more in appearance than the adult males of other genera. By the gradual distension of the body the lateral and posterior margins are made to project more or less beyond the dorsal shield. Moreover, the males of most species of *Eurhipicephalus* protrude a prominent caudal appendage as they distend, the presence of which can scarcely be detected in specimens which have not fed for many days. The males of the three species of *Boophilus* which we recognise in South Africa have all a well-developed caudal appendage as soon as they assume the adult form.

Eurhipicephalus appendiculatus appears to be a general feeder on warm-blooded animals. The adult, we know, readily attacks the ox, horse, mule, sheep, goat, dog, rabbit, and man; we have not tried any stage on birds of any kind. The larva and nymph attach almost anywhere on the skin: the adult shows remarkable partiality for the hairy margin of the ear, but we find that it will attach and develop quite as well on the scrotum. The adult-larva stage has taken only thirty-nine days in the incubator, and from forty-five to eighty-six days at ordinary temperature. Both moults are passed off the host. The larva and nymph may both become full-fed in three days, but usually take five or more. The adult female may feed up in four days, but usually takes at least eight. The larva-nymph stage has taken only ten days in the incubator, twenty-one at office temperature in summer, and forty-one to forty-four at office temperature in winter. The nymph-adult has taken eleven days or more in the incubator, and thirty-one to 100 at office temperature. The species leaves the host at death. Some half-fed nymphs which left a dead ox retained their vitality in a corked tube for over seven months. Unfed

larvæ have remained active for nearly seven months. Some unfed nymphs that dropped as larvæ from oxen in late July of last year, and some unfed adults that dropped as nymphs on April 2 and 3, 1904, are alive at the time of writing (August 10, 1905). *E. nitens* may be only a varietal form of the last species, but we think it distinct. The habits are very similar, but more specimens of the adult are found on the face, and the nymphs appear to take longer to feed.

The behaviour of *E. evertsi* is unlike that of any other tick, so far as we know. The first moult is passed on and the second off the host. The species appears a general feeder on mammals, being common on farm animals and taking readily to the dog, rabbit, and hare; but whatever the host, the larva and nymph are rarely found except deep within the ear. The adult is rarely, if ever, found in the ear, but by choice attaches in the vicinity of the anus or to other hairless oily parts. The adult-larva stage has taken twenty-nine to ninety-five days at ordinary temperature. The nymph comes away eleven days or more after the attachment of the larva, and the adult female six days or more after being applied with a male. The nymph-adult stage takes only eleven days in the incubator, but our lowest ordinary temperature record is twenty-three days.

Eurhipicephalus capensis is common on many parts of the body of the ox, goat, horse, and dog as an adult, though particularly in the case of cattle, on the dewlap, udder, and tail. The larva appears much less easily suited, and numerous attempts to feed it on the goat and ox have failed, not one in ten thousand specimens distending itself. On the dog the larva feeds very satisfactorily, but, curiously, applications to very young pups have usually failed. The nymph feeds freely on the ox. The adult-larva stage in our rearings has taken forty three days and upwards, the larval feeding three days and over, the larval-nymph stage twenty-three days at office temperature, the nymphal feeding three to five days, the nymph-adult stage twelve days in the incubator, and the adult female feeding seven days.

Our attempts to rear *E. simus* have shown that the larva of this species is also hard to please. The adult attacks and develops on many animals, but seems to do much better on the dog than on cattle, horses, goats, or sheep. It is found all over the body of the dog, but usually only about the feet and tail of the ox, so far as we have noticed. The nymph feeds readily on the ox, but very few of the innumerable larvæ that we have applied in various tests have fed on this animal. The dog is suitable as a host for all three stages, and the larva has seemed to do well on the rabbit. Our only adult-larva record preserved shows a duration of fifty-three days for this stage. The larva has fed to repletion in two days, the nymph in three, and the adult female in nine Larvæ have moulted in the incubator in six days, nymphs in fourteen. This species appears to require greater warmth and humidity than the other South African species of *Eurhipicephalus*, and in Cape Colony seems practically confined to coast districts in the summer rainfall area. *E. appendiculatus* extends its range much farther towards the dry interior, and *E. capensis* still farther, whilst *E. evertsi* seems able to flourish in parts of the Karroo too dry for any of its cattle-infesting congeners. Under ordinary conditions it is probable that all the species pass through two generations in a year.

The three South African species of *Boophilus* remain affixed to the host during both moults, as do the species of *Boophilus* that have been

investigated in other countries. *B. decoloratus* is by far the most common of all the South African ticks, but it is unable to thrive on the dry plateaux and where the rainfall is scanty. The ox is its chief host, but it freely attacks the horse, ass, sheep, and goat, and has been fed to maturity on the dog. In the southern districts of Cape Colony another *Boophilus* is found in abundance on cattle. This species appears to differ in no character from the *Boophilus* found on cattle in Queensland. Neither do we find any essential difference between it and *B. microplus* of South America. We shall here refer to it as *B. australis* Fuller, by which name it is known in our records. Both *B. decoloratus* and *B. australis* very closely resemble the type species, *B. annulatus*, not only in structural characters, but also in habits and in the duration of the various life stages. The adult-larva stage occupied twenty-one to twenty-six days in our incubator; at ordinary temperature of the laboratory the extremes recorded are 40 and 146 days for *B. decoloratus* and 35 and 149 days for *B. australis.* The stay of the female on the host, from the time it attaches as a larva to the time it leaves as an adult, is generally twenty-three days; in our numerous records it has varied from eighteen to thirty-eight days. Part of this period is spent in feeding, and part in undergoing the transformations from larva to nymph and from nymph to adult. The nymph and adult attach to the host close to the moulted skin of the previous stage. If the fed larva or fed nymph is removed and kept at the temperature of the air, it takes much longer to moult than if on the host. The male, after feeding a few days, releases its hold and roams about for a mate. He generally remains on the host about a month after reaching maturity. Two to three generations of these species are probably passed in one year.

The third South African *Boophilus* does not appear to have been described. It is much larger than the other species and of distinctive appearance. The horse is its favourite host amongst domestic animals, and when running on the veld it may become very heavily infested during the winter months in many districts of Cape Colony. The ox is said to be little troubled by the species, even where the horse is very much troubled. Few specimens have been found during the summer months. Most complaints of injury come from high inland districts, but the true explanation of this fact may be that greater numbers of horses are raised there than in other parts—not that the climatic conditions are more favourable for the species than at the coast. The adult-larva stage in our laboratory has taken 186 to 201 days; on the veld it probably takes even longer. Attempts to force development in the incubator have failed, all of the numerous females of this species that have been exposed having soon perished. Very little success has attended attempts to feed larvæ in the summer, and hence it is suspected that the species normally passes through one generation only in the year.

In closing this paper I wish to mention that there are doubtless many more species of ticks to be collected at the Cape than are here discussed. It is even probable that I have overlooked some species occurring commonly on cattle. Doubtless, too, many features of interest in the life-cycles and host habits of even the species best known yet remain to be disclosed.

Report on an Investigation of the Batoka Gorge and Adjacent Portions of the Zambesi Valley. *By* G. W. LAMPLUGH, *F.R.S., F.G.S.*

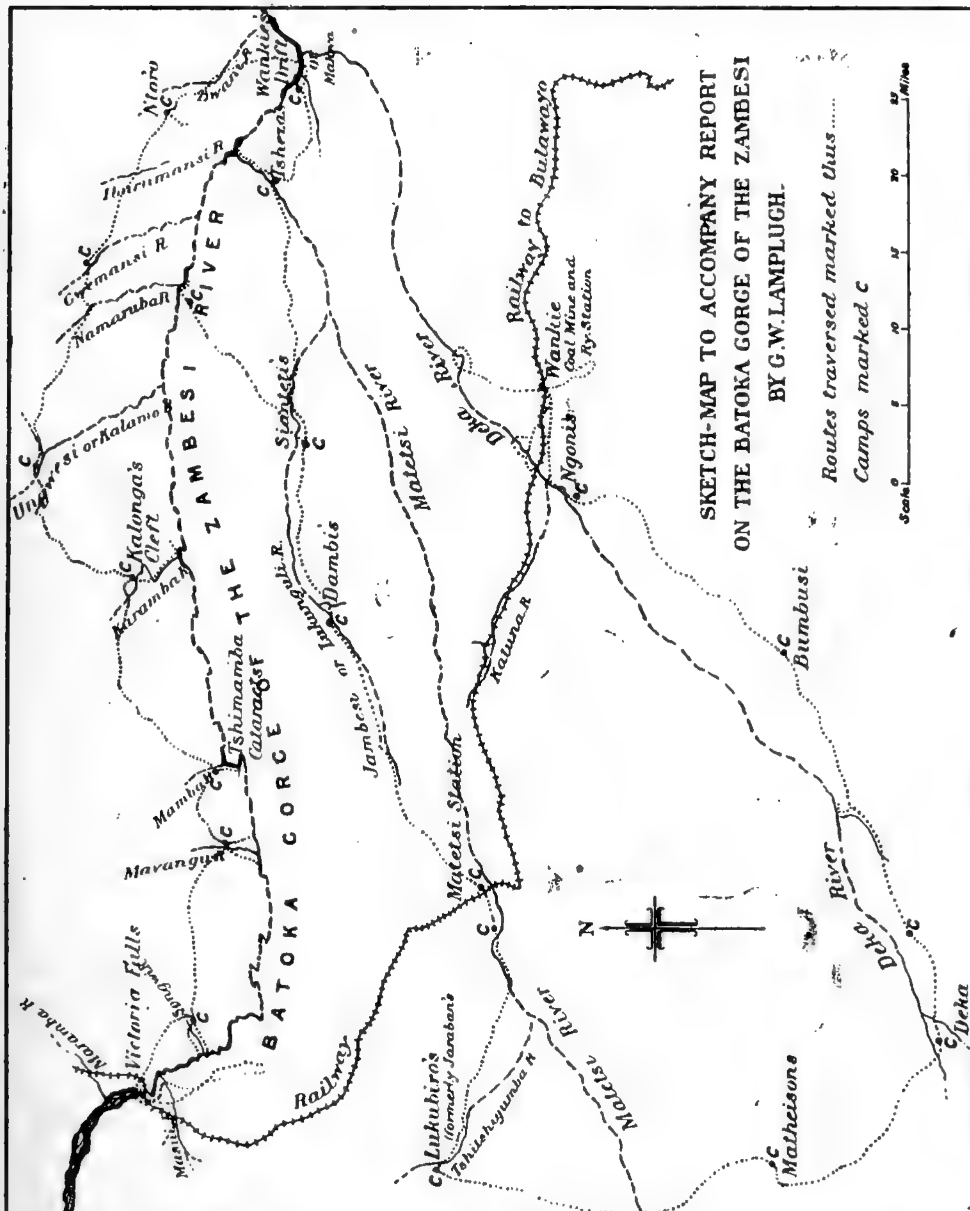
Introduction.—Having undertaken at the request of the Council of the Association to examine the geological structure of the country around the Victoria Falls of the Zambesi River before the meeting of the Association in South Africa last summer, I made a preliminary study of the literature, and found that there were two essential matters on which our information was very inadequate. The first was with respect to the origin of the Falls themselves and the reason for the singularly erratic conformation of the gorge immediately below the Falls. The second was as to the course of the great river for 70 or 80 miles below the Falls, respecting which there appeared to be nothing definitely known. I therefore proposed to devote the short time at my disposal mainly to the elucidation of these two matters.

Before I left England, however, fresh information became available on both points that enabled me to modify and extend my plans. Strong evidence was brought forward by Mr. A. J. C. Molyneux, of Bulawayo, in an able article on 'The Physical History of the Victoria Falls,' published in the 'Geographical Journal' for January 1905, to prove that the majestic waterfall and its concomitants have been slowly developed by the erosive power of the Zambesi itself, and not by the sudden opening of a zigzag crack in the earth's crust by subterranean forces, as all previous travellers, adopting the opinion of David Livingstone, had supposed. My own investigations have fully corroborated Mr. Molyneux's conclusions in this matter by confirmatory evidence gleaned in the immediate vicinity of the Falls, and still more by evidence gained from examination of the rough country below them. With regard to this country, although no description of the Zambesi valley for the space of about 70 miles intervening between the Victoria Falls and Wankie's Drift has been published, the authorities of the British South Africa Company in London most courteously communicated to me the substance of a manuscript report prepared by their distinguished officer, Mr. F. W. Sykes, the District Commissioner at Livingstone, who had succeeded three years ago in penetrating the previously untraversed ground bordering the left or northern bank of the river for a distance of some 40 miles to the eastward of the Falls. This report and the beautiful photographs by which it was illustrated afforded an excellent basis for the study of the physical configuration of the country, and enabled me to appreciate beforehand the nature of the problems that required investigation.

Route.—I reached Victoria Falls on July 2, where, through the kindness of Sir Lewis Mitchell, I found that preparations had been already made by Mr. Sykes for the equipment of an expedition to enable me to investigate the wild country into which the Zambesi disappears after its waters are gathered into the deep gorge below the Falls. Through the hearty co-operation of Mr. Sykes, who, at much personal inconvenience, undertook to conduct the expedition through the country north of the river, native porters were at once called in, and the final preparations soon made. It was arranged that during the earlier stages of the journey we should enjoy the companionship of Lieutenant T. A. G. Budgen, in

command of a detachment of native police. It also happened that Colonel Frank Rhodes, who took a very keen interest in everything pertaining to this region, was at this time visiting the Falls with the intention of making a further journey into the veld, and to our great satisfaction he expressed his readiness to join us.[1]

Starting from the Falls on July 7, we followed the route, along the



left bank of the river, roughly indicated on the accompanying sketch map. Our first camp was pitched at the Songwi stream, seven miles

[1] With the memory of his genial companionship fresh in mind, it was with deep sorrow that during my homeward voyage I learnt of the untimely death of Colonel Rhodes at Cape Town on September 21, just two months after we had parted at Wankie's Drift.

distant from the Falls, where we were able, with some difficulty, to make a descent into the main gorge. Our next march carried us to the Mavangu streamlet, some 12 miles farther south-eastward, where we again reached the brink of the gorge and investigated its structure, but did not attempt to descend its precipitous walls. Thence, making a détour to avoid the intervening lateral gorges of the tributaries, which break backward farther and farther into the plateau as their distance below the Falls is increased, we journeyed for eight or ten miles to a camping-place on the nearly dry bed of the Mamba stream. From this camp we reached the main gorge and again descended into it, the walls, here about 600 feet in height, being less steep than in the higher reaches, owing to the prolonged action of subaërial weathering. At this place, known to the natives as the Tshimamba, the swift Zambesi forms two cataracts, in the lower and larger plunging with a vertical drop of 20 feet into a narrow gully, not more than 25 yards wide, within which the whole river is confined except at flood-times. These cataracts were visited by David Livingstone in 1860; and this appears to be the only part of the Batoka Gorge (as we propose to name the cañon of the Zambesi below Victoria Falls) that was ever penetrated by the white man until Mr. F. W. Sykes's expedition of 1902.

East of the Tshimamba, although the walls of the gorge are no longer so continuously precipitous and are probably scalable in most places, it becomes exceedingly difficult to reach its margin, owing to the wide belt of broken country seamed with impassable ravines that borders it on both sides. In our next march we swung northward for several miles to avoid this country before going east again to the Karamba stream, where we pitched our camp just above the spot where the little river drops suddenly from its open valley on the plateau into a gloomy chasm only 15 or 20 feet wide at the bottom, with towering walls of basalt 300 feet in height. The Karamba, after passing through this chasm (which we propose to name Kalonga's Cleft), flows in a zigzagging ravine for about five miles before joining the Zambesi. With considerable difficulty we managed to make our way to the confluence, but found, contrary to our expectation, that the basalts were still the only rocks exposed in the Batoka Gorge. We then decided, as time was pressing and supplies for our carriers running short, to press eastward to the termination of the basalt country before again attempting to reach the gorge. In adhering to this plan we found that the basalts were continuous to Wankie's Drift, so that we did not again touch the Zambesi until this place was reached, after four days of hard marching. The first of these days carried us some 14 miles N.E. from our Karamba camp to the banks of the Ungwesi River, the largest northern affluent of the Zambesi that we crossed; on the second evening we encamped on the Gwemansi, another important tributary, about 16 miles, as the crow flies, farther eastward; thence, on the third day, our course lay south-eastward for about 13 miles to 'Ntoro; and on the fourth day an easy march of 12 miles brought us down to the Zambesi at Wankie's Drift, which was reached on July 20. Until we reached the Ungwesi not only was the country-rock composed entirely of the basaltic series, but the stream-beds draining from northward also showed no trace of detritus other than that derived from the basalts. In the bed of the Ungwesi, however, there were a few small pebbles of granite and other igneous and metamorphic rocks, which denote that its head-waters probably reach back northward beyond the edge

of the basalts; and these pebbles, along with others of red sandstone and conglomerate, became very numerous and larger in size in the beds of the Gwemansi and three or four other streams east of the Ungwesi, showing that in this quarter we were approaching still nearer to the edge of the basalts. But in the last two streams which we crossed before reaching Wankie's Drift, the Iburumansi and the Bwani, I saw none of these extraneous pebbles.

At Wankie's we were ferried by the natives to the south bank of the river in a small 'dug-out' canoe. Here, although basalt is still the country rock, the Zambesi has again expanded into a wide placid stream, dotted with islands, in an open valley; and I afterwards found that the deep trench-like Batoka Gorge terminates rather suddenly about ten miles above this place.

It had been arranged that Mr. H. F. Greer,[1] the British South Africa Company's officer who holds charge in the district south of the Zambesi, should meet us at the Wankie's crossing, and we found him awaiting our arrival. On the following day Mr. Sykes and Colonel Rhodes struck southward along the Deka valley to reach the railway at Wankie Coal Mine, 35 miles distant, while Mr. Greer and myself took a westerly course parallel to the Zambesi (see sketch map). The subsequent journey was facilitated by the use of horses, which was impracticable in the rough and generally trackless country north of the river. On July 21 we camped in the deep valley of the Matetsi River, four or five miles above its junction with the Zambesi; and next day we explored this valley down to its confluence with the main river. It is a little above this place that the Batoka Gorge terminates and the Zambesi can expand again in a comparatively open valley.

After another long day's journey westward we again turned north, and succeeded in reaching the Batoka Gorge and descending into it at a point some 20 miles east of the nearest place at which it was entered from the north bank. The cañon proved here to be over 700 feet in depth, with characteristics essentially similar to those farther eastward, and entirely in the same basaltic rocks. From this place we travelled rapidly south-westward over the broken plateau to Mr. Greer's head-quarters near Matetsi Station on the railway, which was reached on July 26.

Not having succeeded in obtaining any evidence as to the stratigraphical position of the basalts, I desired to go southward to near the head-waters of the Deka River, where previous information had led me to expect that their base would be found; and Mr. Greer having most kindly undertaken to escort me to this place, we started out from Matetsi again on July 28. We followed a devious route in order to take advantage of the open trails, gathering on the way much information regarding the upper drainage system of the Matetsi basin, and after travelling about 70 miles reached Mr. Giese's ranch, near the site of the old hunter's post known as Deka, after dark on July 31. I was disappointed next day to find here no trace of the termination of the basalts, which must extend southward beneath the surface deposits of

[1] While this is passing through the press, the sad news has been received that Mr. Greer died at Wankie on February 3 last, cut down before reaching his prime by the dreaded black-water fever. After our comradeship on the veld and the enjoyment of his friendship, my appreciation of the high qualities of Mr. Greer was such that this news brings an inexpressible sense of personal loss.

the northern part of the Kalahari region, on the verge of which we now found ourselves.

It had been our intention to return from Deka to Victoria Falls by the old traders' road past Pandamatenka and Gasuma; but as the Bushmen reported that the exceptionally dry season had exhausted the waters of Gasuma Vley this plan became impracticable, and we therefore turned north-eastward and pursued a course roughly parallel to the Deka River for a distance of about 55 miles to the Wankie Coal Mine and Railway Station, which we reached on August 4. We suddenly passed off the basalts on to the sandstones and shales associated with the Wankie Coal Measures after crossing the Deka six miles west of Wankie; and I therefore remained for four days longer in this district to investigate its geological structure more closely, profiting greatly during my stay from the guidance and kind hospitality of Mr. J. M. Kearney, the manager of the mine.

My camping work, rendered possible through the unstinted assistance generously afforded by the British South Africa Company and its officers, terminated at this point, after having extended over 600 miles of actual trekking.

Then returning by railway to Victoria Falls I spent a few more days in examining the head of the gorge and its surroundings; and left there finally on August 18 in order to join the meeting of the Association in Johannesburg, where a preliminary report of my investigation was presented.[1]

The material collected during the journeys above outlined includes a large number of geological specimens, ancient stone implements, and some recent fresh-water shells. As much of this material still remains to be worked out, and as it is intended subsequently to prepare a fuller account of the scientific results, it will suffice for the present to give only a brief forecast of these results.

Geographical and Physiographical Features.—The only maps of the region at present available are merely sketch maps pieced together from travellers' scanty records; and even for the country south of the Zambesi, about the head-waters of the Matetsi and Deka Rivers, which has been frequently traversed, the best existing map is very inaccurate; while for the course of the Zambesi itself and the country to the north of it between Victoria Falls and Wankie's Drift the mapping is frankly hypothetical.

After entering the Batoka Gorge below the Falls the Zambesi, with many sudden curves and sharp-angled bends, pursues on the whole a southerly or south-south-easterly course for 10 or 12 miles. Then turning eastward it appears to follow an average easterly course for about 20 miles, though with some remarkable windings that have as yet been only approximately traced. Its twisting channel afterwards begins to screw northward, with an average east-north-easterly direction, and apparently continues in this general course for nearly thirty miles, to a little beyond the confluence of its northern tributary, the Ungwesi. It then swings round, still with many sharp windings, to an east-south-east and south-easterly direction, in which it continues to Wankie's Drift (see sketch map). Its general course between Victoria Falls and Wankie's is thus

[1] An abstract of this report has been published in *Nature*, vol. lxxiii. pp. 111–114 (November 30, 1905).

resolved into two great curves, the first with its convexity toward the south, and the second, convex toward the north.

Except in the upper part of the southerly bend below the Falls, the general direction of the numerous tributaries which join the Zambesi from the north in the country traversed is from north-west to south-east, though the deep ravines into which they plunge on approaching the Zambesi often reproduce in miniature the erratic zigzags of the main gorge. In its wider aspect this part of the country exhibits a tree-clad plateau of basalt sloping gradually toward the south-east, edged on the north by broad smooth 'bults' of thick red sand resting on the basalt and clad with larger trees. This plateau is broken by wide shallow valleys of low gradient, whose flat bottoms are generally covered with two or three feet of blackish loam which supports a luxuriant growth of tall rushy grass without trees; but as they approach the Zambesi these open valleys break away into the deep precipitous ravines already described; and it is important to note that the length of these ravines was found to increase steadily as we journeyed eastward from Victoria Falls.

It is clear that the open valleys represent a mature stage of the tributaries in their relation to the trunk-drainage, similar to that which still exists in the tributaries that join the Zambesi above the great Falls, and that the cañons in which they now terminate are a measure of the erosion which has taken place since the streams were rejuvenated by the gradual backward excavation of the Batoka Gorge. Owing to this rejuvenation a gradually widening belt of the plateau which borders upon the main gorge has become exceedingly rent and stony from the washing away of the surface soil down the spreading network of gullies; but the level spaces of limited extent that have not yet come under this influence possess, where not covered with the surface-sands, a firm red lateritic soil derived from the decomposed basalt.

That the Batoka Gorge itself has been carried gradually backward into the heart of the plateau by the erosive agency of the Zambesi in its rapid descent from the basaltic upland is further shown by the falling off in the angle of slope of its sides as we descend the river. At Victoria Falls, where the gorge is freshly cut, its walls are practically vertical; but a few hundred yards below, they are already beginning to show the effect of weathering by the slight recession of their crest line and by indications of terracing along the planes of stratification. Seven miles farther down, this recession and terracing become so pronounced that the average angle of slope from base to crest is reduced to 60° or less; thirty miles below the Falls, it is no more than 35°; and farther eastward, the sides of the gorge have been weathered down into bushy slopes, broken here and there by low bars of crag, with an average inclination of 30° or under.

The basaltic country traversed south of the Zambesi, while presenting the same general features as that north of the river, differs from it in some respects, owing to the comparatively great antiquity of its low-level drainage. The Matetsi and the Deka run much more obliquely to the general course of the Zambesi than do the northern tributaries. Thus the Matetsi leaves only a narrow wedge of country to drain directly to the main river, and itself draws many streams from the southern side of this wedge. It makes its confluence with the Zambesi, as we have already seen, below the eastern termination of the great gorge, while the Deka's confluence lies still farther eastward; so that these rivers have had time, not only to carve out long deep valleys into the plateau, but to develop wide drainage basins

around these valleys. But even under these conditions it is not a little remarkable that the Matetsi basin should constitute the most conspicuous feature in the physiography of the basalt country, and should apparently be more pronounced than that of the Zambesi itself. Except in the first few miles below the Falls, where a shallow outer valley is traceable, the Batoka Gorge and its laterals trench so sharply into the plateau that one can rarely be aware of their position until one reaches their very brink; while the Matetsi, nearly up to its head, lies within a great basin that is recognisable long before we reach the river. This peculiar conformation of the country deserves further investigation.

It is noteworthy, as was long ago pointed out by Chapman,[1] that the course of the Deka River for a long distance very nearly coincides with the junction of the basalt with the sandstone. My examination of this junction north and west of the Wankie Coalfield showed that the sandstone is locally indurated to quartzite along the line of the great fault that forms the boundary of the two formations, and that although in the portion examined the river impinges several times upon this hard belt, it always recoils again upon the more perishable basalts. The prolongation of this fault-plane north-eastward may very possibly account for the great northerly bend made by the Zambesi immediately below the confluence of the Deka.

Geology.—The main geological features of the country have been already stated incidentally. The basalts, named by Molyneux the 'Batoka Basalts,' that occupied all except about 80 square miles of the 2,000 square miles embraced within my traverses, represent a succession of ancient lava-flows that have extended far beyond the region examined. In their prevalent characters these basalts are remarkably uniform, consisting generally of thick bands of close-grained dark-blue rock alternating with red, purple, or ashy-looking amygdaloidal bands which mark off the surfaces of the separate flows. These less massive bands frequently show a fragmental structure and occasionally pass into fine or coarse agglomerates suggestive of volcanic tuffs or ashes; but I think that this structure probably represents the 'flow breccia' produced by the breaking up of the solid crust of the lava streams during the onward movement of their still-fluid interior. I sought for interstratified sediments among the basalts, but found none; though, judging from the aspect of some of the railway cuttings in the Katuna valley, west of the Deka, it is not improbable that such may occur in parts of the plateau that I had no opportunity to examine. Certain thin flaggy sandstones that were encountered in patches on the watershed between the Deka and the Matetsi appeared to be newer than the basalts. Nothing was seen to indicate the position of the volcanic vent or vents from which the immense lava-flows have been poured; and it is probable that, like similar 'plateau basalts' in other parts of the world, they have had their source in fissure-eruptions. Their original thickness in the lower part of the Batoka Gorge cannot have been less than 1,000 feet, and may have been very much more.

The basalts, wherever examined, were strongly jointed; but columnar structure was only rudely developed and not prevalent. The main joints form a remarkably regular and persistent system, striking approximately

[1] *Travels in the Interior of South Africa.* London, 1868, vol. ii. p. 213.

east and west over wide areas; and the basalts are also fractured in the same direction by numerous strongly marked vertical planes along which the rock is more or less crushed and veined, that evidently mark lines of faulting. It is to the presence of these joints and faults that the sudden and acute bends of the Zambesi and its tributaries in their gorges below Victoria Falls are mainly due, as the erosive agencies work selectively upon these weak planes, so that the running waters tend to sink deeply along them. This result of differential erosion is especially marked when the weak planes run transverse to the general direction of the stream. Thus at the Falls, the awe-inspiring chasm into which the Zambesi is precipitated has been hollowed out along a vertical east-and-west fracture, which, as I discovered on descending to the bottom at the 'Eastern Recess,' is filled with calcite and other soft vein-material between walls of shattered and partly decomposed basalt.

The 'Deka Fault,' by which, as already mentioned, the Batoka Basalts are abruptly truncated along the Deka River, proved in the portion examined to strike E.N.E. to W.S.W., and must, I think, have its downthrow on the N.N.W. or basalt side. The downthrow was not, however, directly deducible from the evidence yielded by the fault itself, but from evidence obtained in the Wankie Coalfield and on other grounds that will be discussed in a later communication. This fault appears to be the most important feature in the structural geology of the region.

From the Wankie Coal Measures I collected some fragmentary plant-remains, and among these *Vertebraria* has been recognised by Mr. A. C. Seward, F.R.S., who kindly examined them for me. This supports the suggestion of Mr. Molyneux [1] that the Wankie Coal Measures, like other Rhodesian coalfields, are of Permo-Carboniferous age. The Batoka Basalts, by their position in regard to these rocks, are shown to be newer, but their age within narrower limits has not yet been satisfactorily determined.

The surface-deposits of sand, sandy limestone, and cellular quartzite which locally overlie the basalts in the traversed part of the Zambesi basin are evidently analogous to the superficial formations of the Kalahari Desert recently described in great detail by Dr. S. Passarge.[2] Their mode of occurrence in this region does not, however, seem to indicate the regular sequence of events deduced by Dr. Passarge from his study of the Kalahari formations; for, although the thick red sand must have been accumulated under conditions different from those which now prevail, the patches of limestone and quartzite which I examined appeared to me to be assignable to local circumstances that still exist.

I was impressed throughout my traverses with the singular scantiness of alluvial deposits in places where the conditions seemed favourable to their extensive accumulation by fluviatile agency. It was also remarkable that, although the region was tenanted until very recently by extraordinary numbers of the larger mammals, not a single bone or tooth of these animals rewarded my search in the dry river-beds and other likely spots. The peculiar conditions of climate that retard the accumulation of alluvium seem also very rapidly to destroy even the less perishable relics of organic life.

Fuller information on several of the points touched upon in these

[1] *Quart. Journ. Geol. Soc.*, vol. lix. (1903), p. 283.
[2] *Die Kalahari.* Berlin, 1904.

notes will be included in a separate paper, now in preparation, on the geology of the district.

The rock specimens that were collected have been handed over to the Petrological Department of the Geological Survey at the Jermyn Street Museum, where they will be preserved for reference.

Ancient Stone Implements.—On the low ground bordering the Zambesi, just above Victoria Falls, I noticed many rudely chipped implements of chalcedony and agate, upon the low bosses of weathered basalt that rise slightly above the alluvial soil of the flat. These were usually associated with rounded pebble-like stones of like composition, that appear to be the relics of ancient river gravel, and some of the implements themselves showed signs of wear, as if by river action. I afterwards found similar implementiferous ground in patches along the crest of the gorge on both sides for several miles below the Falls, generally lying within the broad shallow depression which appears to represent the ancient high-level valley in which the Zambesi flowed before the Batoka Gorge was excavated. The implements are particularly abundant on the high flat spurs that lie between the zigzags of the gorge immediately below the Falls. A few were also found in parts of the country distant from the main river, but nowhere in such abundance or in the same worn condition as in the neighbourhood of the Zambesi above and below the Falls.

I made a small collection of these implements, which was exhibited at the meeting in Johannesburg, and will be eventually handed over to the authorities of the British Museum. Other collections were subsequently made by members of the Association who visited the Falls, and attention has been drawn to the subject in short papers written by Col. H. W. Feilden [1] and Mr. J. P. Johnson.[2]

If any of the implements found below the Falls have really reached their position when the Zambesi still flowed over their present sites, as seems probable, they must be of very considerable antiquity, and will deserve the careful attention of anthropologists. I have therefore embodied all the facts relating to these implements that came under my notice in a separate paper, which has been communicated to the Anthropological Institute and will be published shortly.

Recent Fresh-water Shells.—Empty shells of fresh-water mollusca were plentiful on some of the dry flood-banks of the Zambesi and its tributaries, and in the beds of desiccated pools or vleys. Specimens of these were collected during my journey, though, as I was unable to find opportunity for obtaining the living molluscs, the shells are not usually in perfect condition, and also probably represent only the commoner forms.

Mr. Edgar A. Smith, of the Natural History (South Kensington) Museum, very kindly undertook the determination of these shells, of which the following is a list, with the localities.

A few conspicuous shells of land snails which were included in the collection were also determined by Mr. Smith: they prove to be all referable to *Achatina immaculata*, Lamarck, and *Achatina Craveni*, Smith.

[1] *Nature*, vol. lxxiii. Nov. 23, 1905, p. 77.
[2] *Trans. Geol. Soc. S. Africa*, vol. viii. (*in the press*).

Fresh-water Shells from the Middle Zambesi Basin.

Species.	Localities.
Melania tuberculata (Müller)	Matetsi River, near mouth.
" sp. allied to *Victoriæ*, Dohrn.	" "
" sp.	Zambesi River, above Victoria Falls.
Lanistes, sp. perhaps a var. of *L. ovum*, Peters	Dry Vley between head-waters of Matetsi and Deka Rivers.
Vivipara capillata, Frauenfeld	Vley in Deka Valley, near Bumbusi; and Bwani River.
Physopsis africana, Krauss	Vley in Deka Valley, near Bumbusi.
Limnæa, sp.	" " "
Planorbis Pfeifferi, Krauss	" " "
Unio zambesiensis, Preston	Zambesi River, at crest of Victoria Falls.
" sp.	Matetsi River; Bwani River; Deka River.
Spatha Wahlbergi, Krauss	Zambesi River, at mouth of Matetsi River; Deka River.
Corbicula astartina, Martens	Deka River; Matetsi River, near mouth.
" *radiata*, Parreyss	Deka River; Bwani River.

In conclusion it is my pleasant duty gratefully to acknowledge the great assistance rendered during the investigation by the officers of the British South Africa Company in Rhodesia and also in London; by the engineers of the Wankie Coal Mine and of the Rhodesia railways; and by many other friends in Rhodesia. To Mr. F. W. Sykes I am peculiarly indebted for removing initial difficulties, and for his unstinted co-operation and guidance in the most difficult part of the work; to Mr. H. F. Greer, for the invaluable assistance which enabled me to carry out the traverses south of the Zambesi; and to Mr. J. M. Kearney, for the facilities afforded me for examining the country around Wankie. To Mr. A. C. Seward, F.R.S., and Mr. E. A. Smith I am indebted, as already mentioned, for the determination of specimens.

Report on Ruins in Rhodesia. *By* David Randall-MacIver.

(Abstract of Lecture delivered at Bulawayo.)

The history of the East Coast is absolutely dark until the tenth century, when, as is known from the chronicle of Kilwa, the earliest of the Mohammedan settlements, Magadoxo was founded. To judge from the scanty documentary evidence available, the Zambesi was quite unknown to the civilised world before the era of Mohammed. Sofala itself was colonised from Magadoxo, and there is no justification, in the absence up to the present of archæological finds, for ascribing its foundation to any more remote date.

From Sofala, or rather from Beira, which has supplanted it within the last generation, is the natural entrance to the interior, where the ruins to be described are situated. The lecturer had explored seven sites, viz., the Rhodes Farm at Inyanga, a place sixteen miles farther north which he had named the Niekerk Ruins, Umtali, Nanatali, Dhlo Dhlo, Khami, and Zimbabwe. Taking these in order he described the results obtained from them, which may be briefly summarised as follows.

The remains at Inyanga consist of pit-dwellings, hill-forts, and

irrigation-trenches. The pit-dwellings are not subterranean, but are structures built up from the ground level. Placed on the slope of a hill they contain, besides the pit with its corridor, a regular series of low stone circles (ordinarily six in number) on the surface of the artificial platform within which the pit and corridor were made. These circles were the foundations of huts, and in them, as well as in the pit, were found articles which proved them to have been inhabited, and that by a Kaffir people. The evidence of many different dwellings, scattered over a great extent of country, from which the results were all consistent, disproves the commonly received idea that such objects were due to casual modern occupation. The explanation of these peculiar structures was furnished by the Niekerk Ruins, an immense settlement over fifty square miles in extent, where they constantly occurred on the tops of hills surrounded by a great system of concentric rings of intrenchment. They are, in brief, *miniature citadels.*

Of hill-forts there are four on the Rhodes estate and two on the Niekerk Ruins. They are built, like the pit-dwellings, of undressed stones without mortar, and their positions crowning steep kopjes have been admirably selected from the military point of view. The ground plans vary, but the unit of construction is the ellipse, often very unsymmetrical, as it has been adapted to all the irregularities of the ground. The most elaborate of the forts is one on the Rhodes estate, which is interesting as being the prototype of such more elaborate buildings as Dhlo Dhlo. Another, on the Niekerk Ruins, shows the origin of the famous 'Parallel Passage' at Zimbabwe: the wooden bolts of its doors were found, one of them in position and still intact. Pit-dwellings, hill-forts, and irrigation-trenches are all contemporary with one another. Many objects were found in excavating them, viz., iron tools and weapons, copper and bronze ornaments, pottery, &c. These are all of types very similar to those used by modern Kaffirs, and nothing was found which an archæologist can recognise either as ancient or as of foreign manufacture. There are no foreign characteristics in the style of the building, but on the contrary there are very close resemblances of detail to Kaffir work.

It should be mentioned that at the Niekerk Ruins was found a most interesting place of offerings which yielded many objects, including stone implements, which were proved in this case to be contemporary with the iron.

Umtali forms the last link in this chain of sites, which seem to be graduated in type as we progress southwards from the Zambesi. For while the most northern region was strongly fortified the necessity for defence seems to grow less further south until at Umtali, though the plans of the buildings are derived from those of Inyanga, yet there are no intrenchments, citadels, or forts. It was at Umtali, near a structure which may be provisionally termed an altar, that Mr. E. M. Andrews discovered an extraordinary collection of magical objects carved in soapstone, including figures of men and women, birds, beasts, &c.

From Umtali the lecturer, accompanied by Mr. E. M. Andrews, proceeded to explore the four other places mentioned, which are more generally known than the northern sites, though not in reality of a different class. The difference is merely that on the more southern sites the buildings are more finished and elaborate. Dhlo Dhlo, for instance, is simply a fortified kraal, the outlying parts of which are built of undressed stone in a style almost as rough as anything at Inyanga, in spite of the fact that

so much care has been expended on the citadel, which is made of slightly dressed stones and ornamented with patterns on the walls. From Dhlo Dhlo there was obtained conclusive evidence of date. An outwork in front of the citadel had been used as a smelting place for tin, a metal which has not been discovered by prospectors in Southern Rhodesia, but is known, on the other hand, to have been imported by the Portuguese. In the same part were found fragments of green glass and of Nankin china. From a great *débris* heap on the side of the citadel were recovered various objects, some of definitely mediæval type, *e.g.*, a pair of iron manacles, which are represented on a sixteenth-century Valencia tile, glass beads (probably Indian), and Nankin china. There was no difference in character between the objects found in the upper and the lower levels of this kitchen midden.

The absolute proof that these specimens belonged properly to the stone buildings in which they were found was furnished by the excavation of a hut-platform inside the entrance of the citadel, which was one of a series occupying the whole interior of the building and inseparably united with the stone walls of the front. Underneath the unbroken cement floor of this hut were found a sheaf of iron weapons with copper bangles, a spindlewhorl, fragments of glass and tin, ivory and glaze beads, and two large fragments of blue and white Nankin china with a flower pattern. This kind of Nankin china is known to be not earlier than the sixteenth century, and is therefore conclusive evidence for the dating of Dhlo Dhlo as actually post-mediæval.

The objects found at Dhlo Dhlo then fall into two main classes, viz., (1) implements, weapons, and ornaments of definitely African character, closely resembling what Kaffirs make at the present day; (2) mediæval imports traded by the Portuguese, chiefly from the Orient.

And there is probably a third class, viz., metal work made by the natives in direct imitation of European processes.

Everything that was observed at Nanatali, Khami, and Zimbabwe is in consonance with what had been discovered at Dhlo Dhlo. Each of these sites yielded the same mixture of definitely native objects with well known and unmistakable mediæval imports. There was not a single specimen which could be described as 'ancient' in the archæologist's acceptation of the word The earliest possible dating for any object found at Zimbabwe is the fourteenth century A.D., and even that (Arabic glass) may quite possibly belong to the fifteenth century. The assertion that there is any superposition of periods at Zimbabwe is erroneous, a blunder on the part of an inexperienced excavator. There has not even been any rebuilding or restoration of walls; the whole place is of a single epoch, and the date of that can be very closely fixed.

Zimbabwe is a royal kraal which differs from other buildings in Rhodesia in no respect save for the greater massiveness of its walls and its more elaborate character. No single stone can have been placed there earlier than the fourteenth or fifteenth century A.D. Merely as an inhabited site the place may have been occupied a few generations longer, but not more. Such a hypothetical settlement would be prior to any of the *buildings* now standing at Zimbabwe, and would be contemporary with the northern sites, viz., Inyanga and the Niekerk Ruins, which the lecturer would ascribe to a century or two before 1500 A.D.

From the character of the objects discovered, and from all the details of construction in the buildings and the dwellings they contained, there

could be no doubt that the Rhodesian ruins were the work of a native race closely akin to those at present inhabiting the country. To identify this race would be a task well deserving of the efforts of investigators. So far from considering that his new conception of the origin and date of these ruins destroyed a romance, the lecturer maintained that they were far more interesting now that they proved to be, not a parasitic growth from Arabia, but products of South Africa itself. Their history is the past history of Rhodesia.

TRANSACTIONS OF THE SECTIONS.

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Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

President of the Section.—Professor A. R. Forsyth, M.A., D.Sc., F.R.S.

CAPE TOWN.

WEDNESDAY, AUGUST 16.

The President delivered the following Address:—

According to an established and unchallenged custom, our proceedings are inaugurated by an address from the President. Let me begin it by discharging a duty which, unhappily, is of regular recurrence. If your President only mentions names when he records the personal losses suffered during the year by the sciences of the Section, the corporate sense of the Section will be able to appreciate the losses with a deeper reality than can be conveyed by mere words.

In Mr. Ronald Hudson, who was one of our Secretaries at the Cambridge Meeting a year ago, we have lost a mathematician whose youthful promise had ripened into early performance. The original work which he had accomplished is sufficient, both in quality and in amount, to show that much has been given, and that much more could have been expected. His alert and bright personality suggested that many happy years lay before him. All these fair hopes were shattered in a moment by an accident upon a Welsh hillside; and his friends, who were many, deplore his too early death at the age of twenty-eight.

The death of Mr. Frank McClean has robbed astronomy of one of its most patient workers and actively creative investigators. I wish that my own knowledge could enable me to give some not inadequate exposition of his services to the science which he loved so well. He was a man of great generosity which was wise, discriminating, and more than modest; to wide interests in science he united wide interests in the fine arts. Your Astronomer Royal, in the Royal Observatory at Cape Town, will not lightly forget his gift of a great telescope: and the University of Cambridge, the grateful recipient of his munificent endowment of the Isaac Newton Studentships fifteen years ago, and of his no less munificent bequest of manuscripts, early printed books, and objects of art, has done what she can towards perpetuating his memory for future generations by including his name in the list, that is annually recited in solemn service, of her benefactors who have departed this life.

In the early days of our gatherings, when the set of cognate sciences with which we specially are concerned had not yet diverged so widely from one another alike in subject and in method, this inaugurating address was characterised by a brevity that a President can envy and by a freedom from formality that even the least tolerant audience could find admirable. The lapse of time, perhaps assisted by presidential ambitions which have been veiled under an almost periodic apology for personal shortcomings, has deprived these addresses of their ancient brevity, and has invested them with an air of oracular gravity. The topics

vary from year to year, but this variation is due to the predilection of the individual Presidents; the types of address are but few in number. Sometimes, indeed, we have had addresses that cannot be ranged under any comprehensive type. Thus one year we had an account of a particular school of long-sustained consecutive research; another year the President made a constructive (and perhaps defiant) defence of the merits of a group of subjects that were of special interest to himself. But there is one type of address which recurs with iterated frequency; it is constituted by a general account of recent progress in discovery, or by a survey of modern advances in some one or other of the branches of science to which the multiple activities of our Section are devoted. No modern President has attempted a general survey of recent progress in all the branches of our group of sciences; such an attempt will probably be deferred until the Council discovers a President who, endowed with the omniscience of a Whewell, and graced with the tongue of men and of angels, shall once again unify our discussions.

On the basis of this practice, it would have been not unreasonable on my part to have selected some topic from the vast range of pure mathematics, and to have expounded some body of recent investigations. There certainly is no lack of topics; our own day is peculiarly active in many directions. Thus, even if we leave on one side the general progress that has been made in many of the large branches of mathematics during recent years, it is easy to hint at numerous subjects which could occupy the address of a mathematical President. He might, for instance, devote his attention to modern views of continuity, whether of quantity or of space; he might be heterodox or orthodox as to the so-called laws of motion; he might expound his notions as to the nature and properties of analytic functionality; a discussion of the hypotheses upon which a consistent system of geometry can be framed could be made as monumental as his ambition might choose; he could revel in an account of the most recent philosophical analysis of the foundations of mathematics, even of logic itself, in which all axioms must either be proved or be compounded of notions that defy resolution by the human intellect at the present day. Such discussions are bound to be excessively technical unless they are expressed in unmathematical phraseology; when they are so expressed, and in so far as such expression is possible, they become very long and they can be very thin. Moreover, had I chosen any topic of this character, it would have been the merest natural justice to have given early utterance of the sibyllic warning to the uninitiated; I must also have bidden the initiated that, as they come, they should summon all the courage of their souls. So I abstain from making such an experiment upon an unwarned audience; yet it is with reluctance that I have avoided subjects in the range which to me is of peculiar interest.

On the other hand, I must ask your indulgence for not conforming to average practice and expectation. My desire is to mark the present occasion by an address of unspecialised type which, while it is bound to be mainly mathematical in tenor, and while it will contain no new information, may do little more than recall some facts that are known, and will comment briefly upon obvious tendencies. Let me beg you to believe that it is no straining after novelty which has dictated my choice; such an ambition has a hateful facility of being fatal both to the performer and to the purpose. It is the strangeness of our circumstances, both in place and time, that has suggested my subject. With an adventurous audacity that quite overshadows the spirit of any of its past enterprises, the British Association for the Advancement of Science has travelled south of the Equator and, in accepting your hospitality, proposes to traverse much of South Africa. The prophet of old declared that 'many shall run to and fro, and knowledge shall be increased'; if the second part of the prophecy is not fulfilled, it will not be for the want of our efforts to fulfil the first part. And if the place and the range of this peripatetic demonstration of our annual corporate activity are unusual, the occasion chosen for this enterprise recalls memories that are fundamental in relation to our subject. It is a modern fashion to observe centenaries. In this Section we are in the unusual position of being able to observe three scientific centenaries in one and the same year. Accordingly I propose to refer to

these in turn, and to indicate a few of the events filling the intervals between them; but my outline can be of only the most summary character, for the scientific history is a history of three hundred years, and, if searching enough, it could include the tale of nearly all mathematical and astronomical and physical science.

It is exactly three hundred years since Bacon published 'The Advancement of Learning.' His discourse, alike in matter, in thought, in outlook, was in advance of its time, and it exercised no great influence for the years that immediately followed its appearance; yet that appearance is one of the chief events in the origins of modern natural science. Taking all knowledge to be his province, he surveys the whole of learning: he deals with the discredits that then could attach to it; he expounds both the dignity and the influence of its pursuit; and he analyses all learning, whether of things divine or of things human, into its ordered branches. He points out deficiencies and gaps; not a few of his recommendations of studies, at his day remaining untouched, have since become great branches of human thought and human inquiry. But what concerns us most here is his attitude towards natural philosophy, all the more remarkable because of the state of knowledge of that subject in his day, particularly in England. It is true that Gilbert had published his discovery of terrestrial magnetism some five years earlier, a discovery followed only too soon by his death; but that was the single considerable English achievement in modern science down to Bacon's day.

In order to estimate the significance of Bacon's range of thought let me recite a few facts, as an indication of the extreme tenuity of progressive science in that year (1605). They belong to subsequent years, and may serve to show how restricted were the attainments of the period, and how limited were the means of advance. The telescope and the microscope had not yet been invented. The simple laws of planetary motion were not formulated, for Kepler had them only in the making. Logarithms were yet to be discovered by Napier, and to be calculated by Briggs. Descartes was a boy of nine and Fermat a boy of only four, so that analytical geometry, the middle-life discovery of both of them, was not yet even a dream for either of them. The Italian mathematicians, of whom Cavalieri is the least forgotten, were developing Greek methods of quadrature by a transformed principle of indivisibles; but the infinitesimal calculus was not really in sight, for Newton and Leibnitz were yet unborn. Years were to elapse before, by the ecclesiastical tyranny over thought, Galileo was forced to make a verbal disavowal of his adhesion to the Copernican system of astronomy, of which he was still to be the protagonist in propounding any reasoned proof. Some mathematics could be had, cumbrous arithmetic and algebra, some geometry lumbering after Euclid, and a little trigonometry; but these were mainly the mathematics of the Renaissance, no very great advance upon the translated work of the Greeks and the transmitted work of the Arabs. Even our old friend the binomial theorem, which now is supposed to be the possession of nearly every able schoolboy, remained unknown to professional mathematicians for more than half a century yet to come.

Nor is it merely on the negative side that the times seemed unpropitious for a new departure; the spirit of the age in the positive activities of thought and deed was not more sympathetic. Those were the days when the applications of astronomy had become astrology. Men sought for the elixir of life and pondered over the transmutation of baser metals into gold. Shakespeare not long before had produced his play 'As You Like It,' where the strange natural history of the toad which,

> 'Ugly and venomous,
> Bears yet a precious jewel in his head,'

is made a metaphor to illustrate the sweetening uses of adversity. The stiffened Elizabethan laws against witchcraft were to be sternly administered for many a year to come. It was an age that was pulsating with life and illuminated by fancy, but the life was the life of strong action and the fancy was the fancy of ideal imagination; men did not lend themselves to sustained and abstract thought

concerning the nature of the universe. When we contemplate the spirit that such a state of knowledge might foster towards scientific learning, and when we recall the world into which Bacon's treatise was launched, we can well be surprised at his far-reaching views, and we can marvel at his isolated wisdom.

Let me select a few specimens of his judgments, chosen solely in relation to our own subjects. When he says:

> 'All true and fruitful natural philosophy hath a double scale or ladder, ascendent and descendent, ascending from experiments to the invention of causes, and descending from causes to the invention of new experiments; therefore I judge it most requisite that these two parts be severally considered and handled'—

he is merely expounding, in what now is rather archaic phrase, the principles of the most ambitious investigations in the natural philosophy of subsequent centuries. When he speaks of

> 'the operation of the relative and adventive characters of essences, as quantity, similitude, diversity, possibility, and the rest; with this distinction and provision, that they be handled as they have efficacy in nature, and not logically'—

I seem to hear the voice of the applied mathematician warning the pure mathematician off the field. When, after having divided natural philosophy into physic and metaphysic (using these words in particular meanings, and including mathematics in the second of the divisions), he declares

> 'physic should contemplate that which is inherent in matter, and therefore transitory, and metaphysic that which is abstracted and fixed; . . . physic describeth the causes of things, but the variable or respective causes; and metaphysic the fixed and constant causes'—

there comes before my mind the army of physicists of the present day, who devote themselves unwearyingly to the properties of matter and willingly cast aside elaborate arguments and calculations. When he argues that

> 'many parts of nature can neither be invented with sufficient subtilty, nor demonstrated with sufficient perspicuity, nor accommodated unto use with sufficient dexterity, without the aid and intervening of the mathematics'—

he might be describing the activity of subsequent generations of philosophers, astronomers, and engineers. And in the last place (for my extracts must have some end), when he expresses the opinion

> 'that men do not sufficiently understand the excellent use of the pure mathematics, in that they do remedy and cure many defects in the wit and faculties intellectual. For if the wit be too dull, they sharpen it; if too wandering, they fix it; if too inherent in the sense, they abstract it; . . . in the mathematics, that which is collateral and intervenient is no less worthy than that which is principal and intended'—

I seem to hear an advocate for the inclusion of elementary mathematics in any scheme of general education. At the same time, I wonder what Bacon, who held such an exalted estimate of pure mathematics in its grey dawn, would have said by way of ampler praise of the subject in its fuller day.

It was a splendid vision of inductive science as of other parts of learning: it contained a revelation of the course of progress through the centuries to come. Yet the facts of to-day are vaster than the vision of that long-ago yesterday, and human activity has far outstripped the dreams of Bacon's opulent imagination. He was the harbinger (premature in many respects it must be confessed, but still the harbinger) of a new era. At a time when we are making a new departure in the fulfilment of the purpose of our charter, which requires us 'to promote the intercourse of those who cultivate Science in different parts of the British Empire,

our Association for the Advancement of Science may pause for a moment to gaze upon the vision revealed three centuries ago in the 'Advancement of Learning' by a philosopher whose influence upon the thought of the world is one of the glories of our nation.

I have implied that Bacon's discourse was in advance of its age, so far as England was concerned. Individuals could make their mark in isolated fashion. Thus Harvey, in his hospital work in London, discovered the circulation of the blood; Napier, away on his Scottish estates, invented logarithms; and Horrocks, in the seclusion of a Lancashire curacy, was the first to observe a transit of Venus. But for more than half a century the growth of physical science was mainly due to workers on the continent of Europe. Galileo was making discoveries in the mechanics of solids and fluids, and, specially, he was building on a firm foundation the fabric of the system of astronomy, hazarded nearly a century before by Copernicus; he still was to furnish, by bitter experience, one of the most striking examples in the history of the world that truth is stronger than dogma. Kepler was gradually elucidating the laws of planetary motion, of which such significant use was made later by Newton; and Descartes, by his creation of analytical geometry, was yet to effect such a constructive revolution in mathematics that he might not unfairly be called the founder of modern mathematics. In England the times were out of scientific joint: the political distractions of the Stuart troubles, and the narrow theological bitterness of the Commonwealth, made a poor atmosphere for the progress of scientific learning, which was confined almost to a faithful few. The fidelity of those few, however, had its reward; it was owing to their steady confidence and to their initiative that the Royal Society of London was founded in 1662 by Charles II. At that epoch, science (to quote the words of a picturesque historian) became the fashion of the day. Great Britain began to contribute at least her fitting share to the growing knowledge of Nature; and her scientific activity in the closing part of the seventeenth century was a realisation, wonderful and practical, of a part of Bacon's dream. Undoubtedly the most striking contribution made in that period is Newton's theory of gravitation, as expounded in his 'Principia,' published in 1687.

That century also saw the discovery of the fluxional calculus by Newton, and of the differential calculus by Leibnitz. These discoveries provided the material for one of the longest and most deadening controversies as to priority in all the long history of those tediously barren occupations; unfortunately they are dear to minds which cannot understand that a discovery should be used, developed, amplified, but should not be a cause of envy, quarrel, or controversy. Let me say, incidentally, that the controversy had a malign influence upon the study of mathematics as pursued in England.

Also, the undulatory theory of light found its first systematic, if incomplete, exposition in the work of Huygens before the century was out. But Newton had an emission theory of his own, and so the undulatory theory of Huygens found no favour in England until rather more than a hundred years later; the researches of Thomas Young established it on a firm foundation.

Having thus noted some part of the stir in scientific life which marked the late years of the seventeenth century, let me pass to the second of our centenaries: it belongs to the name of Edmund Halley. Quite independently of his achievement connected with the year 1705 to which I am about to refer, there are special reasons for honouring Halley's name in this section at our meeting in South Africa. When a young man of twenty-one he left England for St. Helena, and there, in the years 1676–1678, he laid the foundations of stellar astronomy for the Southern Hemisphere; moreover, in the course of his work he there succeeded in securing the first complete observation of a transit of Mercury. After his return to England, the next few years of his life were spent in laying science under a special debt that can hardly be over-appreciated. He placed himself in personal relation with Newton, propounded to him questions and offered information; and it is now a commonplace statement that Halley's questions and suggestions caused Newton to write the 'Principia.' More than this, we know that Newton's great treatise saw the light only through Halley's

persuasive insistence, through his unwearying diligence in saving Newton all cares and trouble and even pecuniary expense, and through his absolutely self-sacrificing devotion to what he made an unwavering duty at that epoch in his life. Again, he appears to have been the first organiser of a scientific expedition, as distinct from a journey of discovery, towards the Southern Seas: he sailed as far as the fifty-second degree of southern latitude, devised the principle of the sextant in the course of his voyaging, and, as a result of the voyage, he produced a General Chart of the Atlantic Ocean, with special reference to the deviation of the compass. Original, touched with genius, cheery of soul, strenuous in thought and generous by nature, he spent his life in a continuously productive devotion to astronomical science, from boyhood to a span of years far beyond that which satisfied the Psalmist's broodings. I have selected a characteristic incident in his scientific activity, one of the most brilliant (though it cannot be claimed as the most important) of his astronomical achievements; it strikes me as one of the most chivalrously bold acts of convinced science within my knowledge. It is only the story of a comet.

I have just explained, very briefly, Halley's share in the production of Newton's 'Principia'; his close concern with it made him the Mahomet of the new dispensation of the astronomical universe, and he was prepared to view all its phenomena in the light of that dispensation. A comet had appeared in 1682—it was still the age when scientific men could think that, by a collision between the earth and a comet, 'this most beautiful order of things would be entirely destroyed and reduced to its ancient chaos'; but this fear was taken as a 'by-the-bye,' which happily interfered with neither observations nor calculations. Observations had duly been made. The data were used to obtain the elements of the orbit, employing Newton's theory as a working hypothesis; and he expresses an incidental regret as to the intrinsic errors of assumed numerical elements and of recorded observations. It then occurred to Halley to calculate similarly the elements of the comet which Kepler and others had seen in 1607, and of which records had been made; the Newtonian theory gave elements in close accord with those belonging to the comet calculated from the latest observations, though a new regret is expressed that the 1607 observations had not been made with more accuracy. On these results he committed himself (being then a man of forty-nine years of age) to a prophecy (which could not be checked for fifty-three years to come) that the comet would return about the end of the year 1758 or the beginning of the next succeeding year; he was willing to leave his conclusion 'to be discussed by the care of posterity, after the truth is found out by the event.' But not completely content with this stage of his work, he obtained with difficulty a book by Apian, giving an account of a comet seen in 1531 and recording a number of observations. Halley, constant to his faith in the Newtonian hypothesis, used that hypothesis to calculate the elements of the orbit of the Apian comet; once more regretting the uncertainty of the data and discounting a very grievous error committed by Apian himself, Halley concluded that the Apian comet of 1531, and the Kepler comet of 1607, and the observed comet of 1682 were one and the same. He confirmed his prediction as to the date of its return, and he concludes his argument with a blend of confidence and patriotism:—

> 'Wherefore if according to what we have already said it should return again about the year 1758, candid posterity will not refuse to acknowledge that this was first discovered by an *Englishman*.'

Such was Halley's prediction published in the year 1705. The comet pursued its course, and it was next seen on Christmas Day 1758. Candid posterity, so far from refusing to acknowledge that the discovery was made by an Englishman, has linked Halley's name with the comet, possibly for all time.

We all now could make announcements on the subject of Halley's comet; their fulfilment could be awaited serenely. No vision or inspiration is needed—calculations and corrections will suffice. The comet was seen in 1835, and it is expected again in 1910. No doubt our astronomers will be ready for it:

and the added knowledge of electrical science, in connection particularly with the properties of matter, may enable them to review Bessel's often-discussed conjecture as to an explanation of the emission of a sunward tail. But Halley's announcement was made during what may be called the immaturity of the gravitation theory; the realisation of the prediction did much to strengthen the belief in the theory and to spread its general acceptance; the crown of conviction was attained with the work of Adams and Leverrier in the discovery, propounded by theory and verified by observation, of the planet Neptune. I do not know an apter illustration of Bacon's dictum that has already been quoted, 'All true and fruitful natural philosophy hath a double scale, ascending from experiments to the invention of causes, and descending from causes to the invention of new experiments.' The double process, when it can be carried out, is one of the most effective agents for the increase of trustworthy knowledge. But until the event justified Halley's prediction, the Cartesian vortex-theory of the universe was not completely replaced by the Newtonian theory; the Cartesian votaries were not at once prepared to obey Halley's jubilant, if stern, injunction to 'leave off trifling . . . with their vortices and their absolute plenum . . . and give themselves up to the study of truth.'

The century that followed the publication of Halley's prediction shows a world that is steadily engaged in the development of the inductive sciences and their applications. Observational astronomy continued its activity quite steadily, reinforced towards the end of the century by the first of the Herschels. The science of mathematical (or theoretical) astronomy was created in a form that is used to this day; but before this creation could be effected, there had to be a development of mathematics suitable for the purpose. The beginnings were made by the Bernoullis (a family that must be of supreme interest to Dr. Francis Galton in his latest statistical compilations, for it contained no fewer than seven mathematicians of mark, distributed over three generations), but the main achievements are due to Euler, Lagrange, and Laplace. In particular, the infinitesimal calculus in its various branches (including, that is to say, what we call the differential calculus, the integral calculus, and differential equations) received the development that now is familiar to all who have occasion to work in the subject. When this calculus was developed, it was applied to a variety of subjects; the applications, indeed, not merely influenced, but immediately directed, the development of the mathematics. To this period is due the construction of analytical mechanics at the hands of Euler, d'Alembert, Lagrange, and Poisson; but the most significant achievement in this range of thought is the mathematical development of the Newtonian theory of gravitation applied to the whole universe. It was made, in the main, by Lagrange, as regards the wider theory, and by Laplace, as regards the amplitude of detailed application. But it was a century that also saw the obliteration of the ancient doctrines of caloric and phlogiston, through the discoveries of Rumford and Davy of the nature and relations of heat. The modern science of vibrations had its beginnings in the experiments of Chladni, and, as has already been stated, the undulatory theory of light was rehabilitated by the researches of Thomas Young. Strange views as to the physical constitution of the universe then were sent to the limbo of forgotten ignorance by the early discoveries of modern chemistry; and engineering assumed a systematic and scientific activity, the limits of which seem bounded only by the cumulative ingenuity of successive generations. But in thus attempting to summarise the progress of science in that period, I appear to be trespassing upon the domains of other Sections; my steps had better be retraced so as to let us return to our own upper air. If I mention one more fact (and it will be a small one), it is because of its special connection with the work of this Section. As you are aware, the elements of Euclid have long been the standard treatise of elementary geometry in Great Britain; and the Greek methods, in Robert Simson's edition, have been imposed upon candidates in examination after examination. But Euclid is on the verge of being disestablished; my own University of Cambridge, which has had its full share in maintaining the restriction to Euclid's methods, and which was not uninfluenced by the report of a Committee

of this Association upon the subject, will, some six or seven weeks hence, hold its last examination in which those methods are prescriptively required. The disestablishment of Euclid from tyranny over the youthful student on the continent of Europe was effected before the end of the eighteenth century.

But it is time for me to pass on to the third of the centenaries with which the present year can be associated. Not so fundamental for the initiation of modern science as was the year in which the 'Advancement of Learning' was published, not so romantic in the progress of modern science as was the year in which Halley gave his prediction to the world, the year 1805 (turbulent as it was with the strife of European politics) is marked by the silent voices of a couple of scientific records. In that year Laplace published the last progressive instalment of his great treatise on Celestial Mechanics, the portion that still remained for the future being solely of an historical character; the great number of astronomical phenomena which he had been able to explain by his mathematical presentation of the consequences of the Newtonian theory would, by themselves, have been sufficient to give confidence in the validity of that theory. In that year also Monge published his treatise, classical and still to be read by all students of the subject, 'The Application of Algebra to Geometry'; it is the starting point of modern synthetic geometry, which has marched in ample development since his day. These are but landmarks in the history of mathematical science, one of them indicating the completed attainment of a tremendous task, the other of them initiating a new departure; both of them have their significance in the progress of their respective sciences.

When we contemplate the activity and the achievements of the century that has elapsed since the stages which have just been mentioned were attained in mathematical science, the amount, the variety, the progressive diligence, are little less than bewildering. It is not merely the vast development of all the sciences that calls for remark: no less striking is their detailed development. Each branch of science now has an enormous array of workers, a development rendered more easily possible by the growing increase in the number of professional posts; and through the influence of these workers and their labours there is an ever-increasing body of scientific facts. Yet an aggregate of facts is not an explanatory theory any more necessarily than a pile of carefully fashioned stones is a cathedral; and the genius of a Kepler and a Newton is just as absolutely needed to evolve the comprehending theory as the genius of great architects was needed for the Gothic cathedrals of France and of England. Not infrequently it is difficult to make out what is the main line of progress in any one subject, let alone in a group of subjects; and though illumination comes from striking results that appeal, not merely to the professional workers, but also to unprofessional observers, this illumination is the exception rather than the rule. We can allow, and we should continue to allow, freedom of initiative in all directions. That freedom sometimes means isolation, and its undue exercise can lead to narrowness of view. In spite of the complex ramification of the sciences which it has fostered, it is a safer and a wiser spirit than that of uncongenial compulsion, which can be as dogmatic in matters scientific as it can be in matters theological. Owing to the varieties of mind, whether in individuals or in races, the progress of thought and the growth of knowledge are not ultimately governed by the wishes of any individual or the prejudices of any section of individuals. Here, a school of growing thought may be ignored; there, it may be denounced as of no importance; somewhere else, it may be politely persecuted out of possible existence. But the here, and the there, and the somewhere else do not make up the universe of human activity; and that school, like Galileo's earth in defiance of all dogmatic authority, still will move.

This complete freedom in the development of scientific thought, when the thought is applied to natural phenomena, is all the more necessary because of the ways of Nature. Physical nature cares nothing for theories, nothing for calculations, nothing for difficulties, whatever their source; she will only give facts in answer to our questions, without reasons and without explanations; we may explain as we please and evolve laws as we like, without her help or her hindrance.

If from our explanations and our laws we proceed to prediction, and if the event justifies the prediction through agreement with recorded fact, well and good: so far we have a working hypothesis. The significance of working hypotheses, in respect of their validity and their relation to causes, is a well-known battle-ground of dispute between different schools of philosophers; it need not detain us here and now. On the other hand, when we proceed from our explanations and our laws to a prediction, and the prediction in the end does not agree with the fact to be recorded, it is the prediction that has to give way. But the old facts remain and the new fact is added to them; and so facts grow until some working law can be extracted from them. This accumulation of facts is only one process in the solution of the universe: when the compelling genius is not at hand to transform knowledge into wisdom, useful work can still be done upon them by the construction of organised accounts which shall give a systematic exposition of the results, and shall place them as far as may be in relative significance.

Let me pass from these generalities, which have been suggested to my mind by the consideration of some of the scientific changes that have taken place during the last hundred years, and let me refer briefly to some of the changes and advances which appear to me to be most characteristic of that period. It is not that I am concerned with a selection of the most important researches of the period. Estimates of relative importance are often little more than half-concealed expressions of individual preferences or personal enthusiasms; and though each enthusiastic worker, if quite frank in expressing his opinion, would declare his own subject to be of supreme importance, he would agree to a compromise that the divergence between the different subjects is now so wide as to have destroyed any common measure of comparison. My concern is rather with changes, and with tendencies where these can be discerned.

The growth of astronomy has already occupied so large a share of my remarks that few more words can be spared here. Not less, but more, remarkable than the preceding centuries in the actual exploration of the heavens, which has been facilitated so much by the improvements in instruments and is reinforced to such effect by the co-operation of an ever-growing band of American astronomers, the century has seen a new astronomy occupy regions undreamt of in the older days. New methods have supplemented the old; spectroscopy has developed a science of physics within astronomy; and the unastronomical brain reels at the contents of the photographic chart of the heavens which is now being constructed by international co-operation and will, when completed, attempt to map ten million stars (more or less) for the human eye.

Nor has the progress of physics, alike on the mathematical side and the experimental side, been less remarkable or more restricted than that of astronomy. The elaborate and occasionally fantastic theories of the eighteenth century, in such subjects as light, heat, even as to matter itself, were rejected in favour of simpler and more comprehensive theories. There was one stage when it seemed as if the mathematical physicists were gradually overtaking the experimental physicists; but the discoveries in electricity begun by Faraday left the mathematicians far behind. Much has been done towards the old duty, ever insistent, of explaining new phenomena; and the names of Maxwell, Weber, Neumann, and Hertz need only to be mentioned in order to suggest the progress that has been made in one subject alone. We need not hesitate to let our thoughts couple, with the great physicists of the century, the leaders of that brilliant band of workers upon the properties of matter who carry us on from wonder to wonder with the passage of each successive year.

Further, it has been an age when technical applications have marched at a marvellous pace. So great has been their growth that we are apt to forget their comparative youth; yet it was only the middle of the century which saw the awakening from what now might be regarded as the dark ages. Nor is the field of possible application nearing exhaustion: on the contrary, it seems to be increasing by reason of new discoveries in pure science that yet will find some beneficent outcome in practice. Invisible rays and wireless telegraphy may be

cited as instances that are occupying present activities, not to speak of radium, the unfolding of whose future is watched by eager minds.

One gap, indeed, in this subject strikes me. There are great histories of mathematics and great histories of astronomy; I can find no history of physics on the grand scale. Some serviceable manuals there are, as well as monographs on particular topics; what seems to me to be lacking is some comprehensive and comparative survey of the whole range. The history of any of the natural sciences, like the history of human activity, is not merely an encyclopædic record of past facts; it reveals both the spirit and the wealth which the past has bequeathed to the present, and which, in due course, the present will influence before transmission to the future. Perhaps all our physicists are too busy to spare the labour needed for the production of a comprehensive history; yet I cannot help thinking that such a contribution to the subject would be of great value, not to physicists alone.

But, as you hear me thus referring to astronomy and to physics, some of you may think of the old Roman proverb which bade the cobbler not to look above his last; so I take the opportunity of referring very briefly to my own subject. One of the features of the century has been the continued development of mathematics. As a means of calculation the subject was developed as widely during the earlier portion of the century as during the preceding century; it soon began to show signs of emergence as an independent science, and the latter part of the century has witnessed the emancipation of pure mathematics. It was pointed out, in connection with the growth of theoretical astronomy, that mathematics developed in the direction of its application to that subject. When the wonderful school of French physicists, composed of Monge, Carnot, Fourier, Poisson, Poinsot, Ampère, and Fresnel (to mention only some names), together with Gauss, Kirchhoff, and von Helmholtz in Germany, and Ivory, Green, Stokes, Maxwell, and others in England, applied their mathematics to various branches of physics, for the most part its development was that of an ancillary subject. The result is the superb body of knowledge that may be summarised under the title of 'mathematical physics'; but the final interest is the interest of physics, though the construction has been the service of mathematics. Moreover, this tendency was deliberate, and was avowed in no uncertain tone. Thus Fourier could praise the utility of mathematics by declaring that 'there was no language more universal or simpler, more free from errors or obscurity, more worthy of expressing the unchanging relations of natural entities'; in a burst of enthusiasm he declares that, from the point of view he had indicated, 'mathematical analysis is as wide as Nature herself,' and 'it increases and grows incessantly stronger amid all the changes and errors of the human mind.' Mathematicians might almost blush with conscious pleasure at such a laudation fo their subject from such a quarter, though it errs both by excess and defect; but the exultation of spirit need not last long. The same authority, when officially expounding to the French Academy the work of Jacobi and of Abel upon elliptic functions, expressed his chilling opinion (it had nothing to do with the case) that 'the questions of natural philosophy, which have the mathematical studyfo all important phenomena for their aim, are also a worthy and principal subject for the meditations of geometers. It is to be desired that those persons who are best fitted to improve the science of calculation should direct their labours to these important applications.' Abel was soon to pass beyond the range of admonition; but Jacobi, in a private letter to Legendre, protested that the scope of the science was not to be limited to the explanation of natural phenomena. I have not quoted these extracts by way of even hint of reproach against the author of such a wonderful creation as Fourier's analytical theory of heat; his estimate could have been justified on a merely historical review of the circumstances of his own time and of past times; and I am not sure that his estimate has not its exponents at the present day. But all history shows that new discoveries and new methods can spread to issues wider than those of their origins, and that it is almost a duty of human intelligence to recognise this possibility in the domain of progressive studies. The fact is that mathe-

matical physics and pure mathematics have given much to each other in the past and will give much to each other in the future; in doing so, they will take harmonised action in furthering the progress of knowledge. But neither science must pretend to absorb the activity of the other. It is almost an irony of circumstance that a theorem, initiated by Fourier in the treatise just mentioned, has given rise to a vast amount of discussion and attention, which, while of supreme value in the development of one branch of pure mathematics, have hitherto offered little, if anything, by way of added explanation of natural phenomena.

The century that has gone has witnessed a wonderful development of pure mathematics. The bead-roll of names in that science—Gauss; Abel, Jacobi; Cauchy, Riemann, Weierstrass, Hermite; Cayley, Sylvester; Lobatchewsky, Lie—will on only the merest recollection of the work with which their names are associated show that an age has been reached where the development of human thought is deemed as worthy a scientific occupation of the human mind as the most profound study of the phenomena of the material universe.

The last feature of the century that will be mentioned has been the increase in the number of subjects, apparently dissimilar from one another, which are now being made to use mathematics to some extent. Perhaps the most surprising is the application of mathematics to the domain of pure thought; this was effected by George Boole in his treatise 'Laws of Thought,' published in 1854; and though the developments have passed considerably beyond Boole's researches, his work is one of those classics that mark a new departure. Political economy, on the initiative of Cournot and Jevons, has begun to employ symbols and to develop the graphical methods; but there the present use seems to be one of suggestive record and expression, rather than of positive construction. Chemistry, in a modern spirit, is stretching out into mathematical theories; Willard Gibbs, in his memoir on the equilibrium of chemical systems, has led the way; and, though his way is a path which chemists find strewn with the thorns of analysis, his work has rendered, incidentally, a real service in co-ordinating experimental results belonging to physics and to chemistry. A new and generalised theory of statistics is being constructed; and a school has grown up which is applying them to biological phenomena. Its activity, however, has not yet met with the sympathetic goodwill of all the pure biologists; and those who remember the quality of the discussion that took place last year at Cambridge between the biometricians and some of the biologists will agree that, if the new school should languish, it will not be for want of the tonic of criticism.

If I have dealt with the past history of some of the sciences with which our Section is concerned, and have chosen particular epochs in that history with the aim of concentrating your attention upon them, you will hardly expect me to plunge into the future. Being neither a prophet nor the son of a prophet, not being possessed of the knowledge which enabled Halley to don the prophet's mantle with confidence, I shall venture upon no prophecy even so cautious as Bacon's—'As for the mixed mathematics I may only make this prediction, that there cannot fail to be more kinds of them as Nature grows further disclosed'—a declaration that is sage enough, though a trifle lacking in precision. Prophecy, unless based upon confident knowledge, has passed out of vogue, except perhaps in controversial politics; even in that domain, it is helpless to secure its own fulfilment. Let me rather exercise the privilege of one who is not entirely unfamiliar with the practice of geometry, and let me draw the proverbial line before indulgence in prophetic estimates. The names that have flitted through my remarks, the discoveries and the places associated with those names, definitely indicate that, notwithstanding all appearance of divergence and in spite of scattered isolation, the sum of human knowledge, which is an inheritance common to us all, grows silently, sometimes slowly, yet (as we hope) safely and surely, through the ages. You who are in South Africa have made an honourable and an honoured contribution to that growing knowledge, conspicuously in your astronomy and through a brilliant succession of astronomers. Here, not as an individual but as a representative officer of our brotherhood in the British

Association, I can offer you no better wish than that you may produce some men of genius and a multitude of able workers who, by their researches in our sciences, may add to the fame of your country and contribute to the intellectual progress of the world.

The following Papers were read:—

1. *Observations on Atmospheric Electricity in South Africa.* *By* Professor J. C. Beattie, *D.Sc.*, J. Lyle, *M.A.*, *and* W. H. Logeman, *M.A.*

The observations carried out up to now consist of a series made at Bloemfontein in 1902–1903 by Mr. Lyle, of the Grey College, Bloemfontein, and a less complete series made during the same period at Cape Town by Mr. W. H. Logeman. Observations have also been carried out in Cape Town by Mr. Fincham during the present year.

The instruments used were an Elster and Geitel dissipation apparatus, and—less regularly—a Kelvin portable electrometer.

The paper contained the records of daily readings of temperature, humidity, pressure, and both positive and negative leaks for morning and afternoon hours. These results are used to determine the annual variation; a harmonic analysis of the results being obtained in the usual way.

Cape Town is on the coast practically at sea-level.

Bloemfontein is inland, and about 4,500 feet above sea-level.

The magnitude of the leak is greater at Bloemfontein than at Cape Town.

The positive leak, both at Cape Town and at Bloemfontein, is less than the negative in the morning; the positive leak in the afternoon in Bloemfontein is greater than the negative in the summer months, less in the winter months. In Cape Town, so far as the observations go, it seems probable that the opposite is true, that is, from June to October the positive leak is greater than the negative, and in November and December less.

Mr. Lyle and Mr. Fincham had in addition observed on several days throughout the whole day. The chief results are similar to those obtained in Europe. Formation of fog leads to a diminution in leak. The rate of leak changes with the relative humidity and with the pressure.

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2. *Apioidal Binary Star-Systems.* *By* Alexander W. Roberts, *D.Sc.*, *F.R.A.S.*—See Reports, p. 249.

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3. *On the Convergence of a Reversed Power Series.* *By* Professor A. Brown, *M.A.*

For some purposes it is useful to have a knowledge of definite limits within which a reversed series converges. The following investigation supplies such a knowledge, though the limits obtained are generally rather narrow.

Start from

$$y = b_1x + b_2x^2 + \dots \qquad (1)$$

which is the series to be reversed, the b's being real.

$$x = \frac{y}{b_1} - \frac{1}{b_1}\{b_2x^2 + \dots\} \qquad (2)$$

If we apply the method of successive approximations we have, first,

$$x = \frac{y}{b_1}.$$

This must now be substituted in equation (2) and a second approximation obtained. The second approximation is now substituted in (2) to obtain a third. If the series thus obtained is convergent it is the reversed series wanted.

Suppose, first, that b_1 is positive.

Then the coefficients of the series obtained by successive approximation are clearly not greater than would be got if all the coefficients of powers of x in (2) were positive, *i.e.*, not greater than the coefficients of reversed series obtained from

$$x=\frac{y}{b_1}+\frac{1}{b_1}\{\beta_2x^2+\beta_3x^3\ldots\} \qquad . \quad . \quad . \qquad (3)$$

where $\beta_n=|b_n|$.

If β is the greatest of the set $\beta_2\beta_3\ldots$ the series from (3) has coefficients certainly not greater than those from

$$x=\frac{y}{b_1}+\frac{1}{b_1}\{\beta x^2+\beta x^3\ldots\}.$$

If b_1 is negative, the numerical value of the coefficients is clearly not diminished if we make every sum on the right-hand side of (2) positive. Combining the two cases, we see that the coefficients of the reversed series are certainly not greater than those obtained from

$$x=\frac{y}{\beta_1}+\frac{1}{\beta_1}\{\beta x^2+\beta x^3+\ldots\}.$$

The coefficients in this last case can be calculated.

We have $$x=\frac{y}{\beta_1}+\frac{\beta x^2}{\beta_1(1-x)},$$

whence $$x^2(\beta+\beta_1)-x(y+\beta_1)+y=0;$$

$$\therefore\ x=\frac{1}{2(\beta+\beta_1)}\{\beta_1+y-\sqrt{\beta_1{}^2-2y(\beta_1+2\beta)+y^2}\},$$

the solution with the negative sign before the square root being evidently the appropriate one.

Now the expression for x will be expansible in a series of powers of y provided

$$\left[1-2y\,.\frac{\beta_1+2\beta}{\beta_1{}^2}+\frac{y^2}{\beta_1{}^2}\right]^{\frac{1}{2}}$$

is so expansible.

Values of y for which this is certainly true are given by

$$2y\,.\frac{\beta_1+2\beta}{\beta_1{}^2}+\frac{y^2}{\beta_1{}^2}<1^*$$

$$\text{i.e., } y^2+2y(\beta_1+2\beta)-\beta_1{}^2<0.$$

The range of positive values of y for which this is true is

$$y<\sqrt{(\beta_1\times 2\beta)^2+\beta_1{}^2}-(\beta_1+2\beta),$$

and for these values of y the series obtained from (1) by reversion will also be convergent.

It is assumed throughout that the value of y is positive; a negative value would be met by changing both sides of (1) and obtaining one or other (b_1+ or b_1-) of the cases discussed.

The series $$y=x+\frac{x^2}{2^1}+\frac{x^3}{3^1}\ldots$$

* Chrystal II. chap. xxvii. § 7.

gives $y = \cdot 236$ as upper limit, it being otherwise known that the reversed series is convergent up to $y = 1$.

The series $$y = x - \frac{x^2}{2} + \frac{x^3}{3} \cdots$$

gives $y = \cdot 236$ as upper limit; the reversed series is actually convergent for all values of y.

It is to be observed that no result is given for the case when any of the b's become indefinitely great, since $\underset{\beta = \infty}{L} \left[\sqrt{(\beta_1 + 2\beta)^2 + \beta_1^2} - (\beta_1 + 2\beta) \right] = 0$, provided $\beta_1 \not< \infty$, a case which does not arise.

The case excepted may be dealt with as follows:—

Suppose $y = b_1 x \ldots + b_n x^n + \ldots$ . . . . (1)

where $b \; = \infty$, and of course the series on the right of (1) is convergent for values of x within a certain region, say $|x| < \rho$.

Then, if σ be any quantity such that $|\sigma| > \rho$ we have $\underset{n . . \infty}{L} \left|\frac{b_n}{\sigma^n}\right| = 0$, and none of the quantities $\left|\frac{b_n}{\sigma^n}\right|$ other than finite.

Transform (1) by the relations $\sigma x = \xi$

$$y = \frac{b_1}{\sigma} \cdot \xi \ldots + \frac{b_n}{\sigma^n} \xi^n + \ldots$$

and we have a series to which the previous reasoning is applicable, and if ξ is expansible in a series of powers of y, then $x = \frac{\xi}{\sigma}$ is also so expansible.

The condition is $y < \sqrt{(\beta_1 + 2\beta)^2 + \beta_1^2} - (\beta_1 + 2\beta)$

where $\beta_1 = \left|\frac{b_1}{\sigma}\right|$ and β is the greatest of the set $\left|\frac{b_n}{\sigma^n}\right|$.

e.g., $y = x + 2x^2 \ldots + nx^n + \ldots$

put $2x = \xi$ $\qquad y = \frac{1}{2} \cdot \xi + \frac{1}{2} \cdot \xi^2 + \frac{3}{2^2} \cdot \xi^3 \ldots$

$\beta_1 = \frac{1}{2} \; \beta = \frac{1}{2}$ $\qquad y < \cdot 15$.

The same principle can also be applied to the first case considered; thus the reversed series of (1) will certainly be convergent for values of x less than the greatest of the quantities $[\sqrt{(\beta_1|\sigma + 2\beta_n|\sigma^n)^2 + \beta_1^2\sigma^2} - (\beta_1|\sigma + 2\beta_n|\sigma^n)]$

where σ is any quantity whatever and $\beta_n|\sigma^n$ is the greatest of the set

$$\beta_1|\sigma, \; \beta_2|\sigma^2, \; \beta_3|\sigma^3 \ldots$$

I am unable to find any general expression for the maximum value of this limit, owing to the difficulty arising from the fact that different values of σ require different β's to be selected to give the greatest coefficient. It is to be observed that the values of the above limit for $\sigma = 0$ and for $\sigma = \infty$ are both zero.

As an example of the limits obtained we have for the case of

$$y = x + \frac{x^2}{2^1} + \; . \; + \frac{x^n}{n^1} \cdots$$

$$\begin{cases} \sigma = \frac{1}{4} \quad \frac{1}{3} \quad \frac{1}{2} \quad 1 \quad 2 \quad 3 \\ y < \cdot 315, \; \cdot 369, \; \cdot 324, \; \cdot 236, \; \cdot 152, \; \cdot 111. \end{cases}$$

The proof can be arranged so as to cover the case of an imaginary variable.

We have
$$y = b_1x + b_2x^2 + b_3x^3 + \ldots \qquad (1)$$
$$x = \frac{y}{b_1} - \frac{1}{b_1}\{b_2x^2 + b_3x^3 + \ldots\} \qquad (2)$$

Suppose now that $\frac{y}{b_1} = \eta + i\xi$, and compare two series (a) the one which would be got from (2) by successive approximation, and (b) the series got by successive approximation from
$$x = \rho + \frac{1}{\beta_1}\{\beta_2x^2 + \beta_3x^3 + \ldots\} \qquad (4)$$
where $\rho = |\eta + i\xi|$ and $\beta_r = |b_r|$.

Using the facts that the modulus of a sum is not greater than the sum of the moduli, and that the modulus of a product or quotient is equal to the product or quotient of the moduli, we see that in the parallel processes for obtaining (a) and (b) any term in (b) is not less than the modulus of the corresponding term in (a).

Hence the reversed series obtained from (1) will be convergent if that obtained from (4) is convergent. By the previous work the condition is
$$\kappa < \sqrt{(\beta_1 + 2\beta)^2 + \beta^2} - (\beta_1 + 2\beta)$$
where $\kappa = |y|$.

The general result is that the reversed series of
$$y = b_1x + b_2x^2 \ \ldots \ + b_nx^n \ \ldots$$
is convergent for all values of y *such that*
$$(y) < \sqrt{(\lambda\beta_1 + 2\lambda^n\beta_n)^2 + \lambda^{2n}\beta_n{}^2} - (\lambda\beta_1 + 2\lambda^n\beta_n)$$
where λ *is any quantity and* $\lambda^n\beta_n$ *is the greatest of the set* $|\lambda b_1|\ |\lambda^2 b_2|\ |\lambda^2 b_3|$.

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4. *On Instruments for Stereoscopic Surveying.* *By* H. G. FOURCADE.

The instruments of which photographs are exhibited have been designed for the construction of topographical plans from stereoscopic photographs of the country. A preliminary account of the method was communicated to the S. A. Philosophical Society on October 2, 1901 (also 'Nature,' June 5, 1902), and a more complete Paper will shortly be published.

If photographs be taken from both ends of a base, at right angles to it and under conditions ensuring perfect parallelism of the line of collimation of the camera in both positions, the co-ordinates of any point common to both pictures may be computed from the plate co-ordinates by means of the simple relations—
$$Y = \frac{b}{e}f,$$
$$X = \frac{b}{e}x,$$
$$Z = \frac{b}{e}z,$$
b being the base, f the focal length of the camera lens, and e the stereoscopic difference—that is, the difference of the plate x's. It is not necessary to have the ends of the base at the same height.

The camera is a metal box provided with levels, a transverse telescope, and a very accurate réseau scale divided on the silvered surface of an optically plane and parallel plate of glass, which may be set in front of the sensitive film for the impression of the réseau lines or raised for the exposure of the view. Two pivots and an end contact on the frame of the réseau plate ensure the geometrically

correct setting of that plate every time it is lowered. The zero of the réseau scale then coincides with the optical axis of the camera, independently of temperature changes. Means are provided for making all the necessary instrumental adjustments.

The image of the réseau scale being projected from the camera lens, ordinary commercial plates with sensible curvatures may be used without detriment to accuracy, since any resulting distortion in the picture is reproduced in the réseau and differentially eliminated in measures for which the réseau supplies the scale. To avoid the inconvenience which varying sizes of réseau intervals would occasion, the plate is placed in the measuring machine at a distance from the microscope objective equal to the focal lens of the camera lens, and with the film in the same relative position, so that runs remain practically constant.

The parallelism of the camera at both stations is secured by the use of two similar stands, on which the camera and a mechanically centred signal are successively interchanged. The transverse telescope is reversed at the second station in a manner eliminating the effect of small errors of collimation or inclination. The principal error remaining is that of bisection, and it may be made very small with a suitable sharply defined signal.

The lens adopted is Zeiss's 'Protar,' of 141 mm. nominal focal length, in a special mounting and with a permanent stop of $f/36$. The plates used are 'Edward's medium isochromatic,' 4×5 inches, and the exposures are made through a dark yellow screen optically plano-parallel. The advantage of cutting off the rays of shorter wave-length which form atmospheric 'blue haze' is that photographs may then be taken showing sufficient detail for purposes of measurement in a range of distance extending to 12 km. or more.

The camera is constructed of an aluminium alloy, and weighs with the changing box and a dozen plates only 14 lbs., so that it is sufficiently portable for mountain work. A 5-inch micrometer theodolite is interchangeable on the same stand, and serves to connect the ends of the base with the triangulation of the country.

The measuring machine is essentially similar in principle to those which are used for the measurement of stellar photographs, except that a pair of plates in stereoscopic combination is measured together. Any portion of the picture may be made to appear in relief, and any point chosen to coincide, apparently in three dimensions, with an index attached to the micrometers. These consist each of a screw moving a glass scale, the intersection of which with a réseau line gives the distance of the point from the line considered. The numbering of the réseau intervals of the scale and of the micrometer heads is arranged to give at sight the successive figures of the reading of a plate co-ordinate to the nearest micron, or by estimation to a tenth of a micron. The micrometer head is then turned back a fraction of a revolution until it butts against a stop, when it is again at its zero and the measurement of the next point may be proceeded with.

The speed of measurement with the machine was found to be, without practice, twenty-five pairs of points an hour.

The mechanical parts of the machine and of the camera were made by Troughton & Simms, the optical parts and the glass scales by Zeiss, and the réseau by Gautier. These firms spared no pains in endeavouring to satisfy the somewhat exacting requirements that were considered necessary for accuracy, and the resulting workmanship of the instrument is very satisfactory.

The p.e. of a single bisection (mean at sight of back and forward rotations of the drums) with either micrometer was found to be, from the residuals of 200 observation equations formed in the investigation of the scale and screw errors, $\pm 0{\cdot}27\mu$ for a mark of best definition. For a réseau line it is $\pm 0{\cdot}43\mu$.

'Ordinary topographical objects being usually ill-defined and irregular, can seldom be bisected accurately with each eye singly, but, stereoscopically, the adjustment of their apparent distance with that of the index can be effected with great comparative delicacy, the p.e. of a stereoscopic bisection being from $\pm 1{\cdot}02$ to $\pm 2{\cdot}65\mu$, according to the class of object, or equivalent to a p.e. of bisection of $\pm 0{\cdot}72$ to $1{\cdot}88\mu$ for each plate.'

The distortion of the camera lens was determined with great precision from

measures of plates. It may be expressed, with a probable error of under one micron, as a function of the radius from the centre of the plate, with the addition of terms representing the effect of the deviation of a central ray in passing along the optical axis of the lens, a deviation due to small errors in centreing of the system of lenses. The symmetrical part of the distortion is nearly represented by a parabola of the second degree.

A 'standard' value of the focal length at a given temperature results from the determination of the distortion. It is the distance on the réseau scale of the silvered surface of the réseau plate from the back nodal point of the lens for small elements of the picture near the centre. The temperature coefficient of that standard, being equal to the difference between the coefficients of expansion of aluminium and glass values for different temperatures of exposure, may be computed and used for all subsequent work.

The corrections for distortion are taken out at sight from a diagram of correction curves over the plate. They become large near the corners of the plate, reaching then 200μ or more.

No other correction is applied to the plate co-ordinates, the remaining errors being treated as accidental. From a discussion of measures it results that the principal sources of these errors and their probable amounts are as follows:—

Error of scale and screw, treated as accidental	$\pm 0{\cdot}3\mu$
Uncorrected distortion of lens and error in taking out distortion from diagram	$\pm 1{\cdot}1\mu$
Distortion of film and error inherent to the photographic image	$\pm 1{\cdot}5\mu$

There are, in addition, errors in the relative orientation of the pair of plates ($\pm 1{\cdot}5\mu$), and in their absolute orientation and that of the base line. The vertical co-ordinate z is estimated on the glass scale to the nearest 10μ, it being unnecessary to measure z with the same accuracy as the stereoscopic difference e.

The combined effect of all the errors on the measures of an ordinary topographical object is:

$$\Delta e = \pm 4\mu, \quad \Delta x = \pm 10\mu, \quad \Delta z = \pm 7\mu.$$

The probable errors in the co-ordinates of a point resulting from these values are as under:—

Y	Δ Y	Δ X	Δ Z
Base 300 m.			
1,000 m.	0·1	0·1	0·1
2,000 „	0·4	0·2	0·1
3,000 „	0·9	0·3	0·2
4,000 „	1·5	0·4	0·3
5,000 „	2·4	0·6	0·4
6,000 „	3·4	0·8	0·6
7,000 „	4·7	1·1	0·8
8,000 „	6·1	1·4	1·0
9,000 „	7·7	1·8	1·2
10,000 „	9·5	2·2	1·4
11,000 „	11·5	2·6	1·7
12,000 „	13·7	3·1	2·0
Base 500 m.			
15,000 m.	12·9	3·0	2·0
Base 1,000 m.			
20,000 m.	11·4	2·8	1·9

A test survey was made, in which the co-ordinates of 265 points were computed from a pair of plates. Of these twenty-five were either determined by independent survey or compared with their positions derived from the overlap of

the next pair of plates having a different base line. The comparison shows that the average errors are of the magnitude given above, or slightly less, and therefore that no important source of error was overlooked in the discussion.

Dr. Pulfrich, of Jena, devised at about the same time, and independently, a stereoscopic method of measurement, described in a paper in the 'Zeitschrift für Instrumentenkunde' for March, May, and August 1902. To the instrument used for the measurement of plates he gives the name of 'Stereo-comparator.' It differs somewhat in design from the measuring stereoscope of the author, and the measurements are referred not to a réseau, but to independent metal scales, recording the relative or absolute displacement of the plates on the machine. In consequence the plates cannot be measured directly when set at an inclination corresponding to that of the base line, which is the condition for combining correctly the pair of pictures. An approximate combination is, however, obtained if one of the plates is moved vertically whenever a measurement is made until the point considered is at the same height on both plates.

According to Colonel Laussedat ('Bull. Soc. française de Photographie,' t. xx., 1904), Baron von Hübl found it necessary, when using the machine for topographical work, to conduct the measurements at a constant temperature, and to control the results by means of a large number of points determined by independent survey. Von Hübl concludes that the method is of limited usefulness in comparison with ordinary photogrammetry. He does not appear, however, to have taken into account the distortion of the lens, which may be considerable.

The accuracy of measures made with a machine of the independent-scale type is limited by:—

(*a*) Errors in the relative setting of the plane of the plates in the camera and in the machine; error in setting the corresponding reference lines on both plates truly parallel; displacement of the horizontal zero setting, when measuring, if the auxiliary vertical slide moving one plate relatively to the other is not perfectly straight and accurately parallel with the reference marks of the supported plate.

(*b*) Errors in the straightness of the other slides introducing, from rotation, unequal displacements of the point observed and of the index of the recording scale placed some distance laterally.

(*c*) Differences between the temperatures at which the plates are exposed, at which they are set to zero in the machine, and at which each measurement is made. The effect of temperature changes is important, since small stereoscopic differences are determined from differences of large lengths, involving the coefficients of expansion of glass, steel, and brass.

(*d*) Curvature of the film. The picture is impressed as a projection from a point in the lens, but is measured orthogonally. The resulting error may be reduced by the use of plate-glass to support the film, but it is not even then rendered negligible when the focal length is not large in comparison with the dimensions of the plate.

On the other hand, none of these sources of error affects measures made with the measuring stereoscope by reference to a réseau scale impressed in the camera. The results are then found to leave little to be desired in point of precision. Ordinary plates may be used and control surveys dispensed with. The speed of measurement is greater than with a scale machine, since all readings are made from the eyepiece, and one setting of the pair of plates, only necessarily approximate enough to produce stereoscopic combination, is sufficient for the whole of the measurements.

It is not expected that the method will displace any of those in present use. There is no universal method of surveying, and the skill of a surveyor is shown in nothing so much as in the correct choice of different methods under different conditions. But it is hoped, nevertheless, that the power and accuracy of the stereoscopic method will justify for it a place in the practice of topographical surveying.

5. *On Japanese Mathematics.* *By* Professor PAUL HARZER.

The astonishing progress of Japanese mathematics in recent years has induced me to seek for signs of any independent mathematical work of the Japanese before their contact with occidental culture in our times. Our knowledge of these ancient times in general comes to us from very scanty sources, not easily accessible; a great part of them are in Japanese, and require very careful criticism; the sources for Japanese mathematics in particular have been, moreover, kept secret by the Japanese mathematicians in the manner of the old Pythagorean school, and have become known to foreigners only in the last few years. Aided by a Japanese scholar, who has translated some Japanese texts for me, I have studied these sources, and am giving you an abstract of the results, which I have laid down in detail in a paper published in the 'Jahresbericht der deutschen Mathematiker Vereinigung,' vol. xiv. p. 312. I may add that in this study of Japanese sources I have never felt any doubt concerning their purity.

The wide extension of the study of mathematics in Japan already in ancient times is to be inferred from the fact that the Imperial Library of Tokio contains more than 2,000 written and printed native mathematical works, going back to the year 1595. It is not surprising that the higher of these works are consecrated to the problem of the quadrature of the circle, which has been the centre of the mathematical efforts of all civilised nations, in such a degree that we may, with an English mathematician, assert that the history of this problem coincides nearly with the history of mathematics in general.

Concerning the Japanese numerical value for π—that is to say, of the ratio of the circumference of the circle to its diameter—we have knowledge of the fraction $\frac{79}{25}$ about the year 1627. On expressing this value in the decimal system of numbers, in use in Japan since olden times, the first two places are right. To the second half of the seventeenth century belong decimal values of the precision of 9 and 10 places. About 1709 there is to be found the famous fraction $\frac{355}{113}$, right to 7 places, and about 1722 and 1739 the precision increases to 42 and 51 correct places. Moreover, about 1766 the two common fractions $\frac{5419351}{1725033}$ and $\frac{428224593349304}{136308121570117}$ were known, representing π with astonishing precision to 12 and 30 places; and already about 1760 there exists the value $\frac{98548}{9985}$ for π^2, which is exact to 9 places.

We are told about some of the methods by which these values were obtained. One form of solution of the problem depends on nearly the same principle as the famous method of Archimedes: an arbitrary arc of the circle is divided into halves, each of the two halves once more into halves, and so on. The chords of these arcs get smaller and smaller, and their sum represents the length of the arc nearer and nearer. Between the chord of the arc and that of the half-arc exists a quadratic equation, by whose solution, repeated for the subsequent chords, Archimedes arrived at a lower limit for π. But whereas Archimedes made this calculation numerically only, one of the Japanese solutions makes use of analytical methods, and obtains its results in the form of infinite series quite in the way of modern higher mathematics. The other type of Japanese solution is connected with the consideration of the sphere, which is, in a manner already used by Archimedes, dissected by parallel planes, quite close to one another, into a large number, *e.g.* 400, of thin layers; and their content is calculated and afterwards summed by elementary means. The connection between these two kinds of solution remained unknown to the Japanese mathematicians up to the year 1709.

To explain Japanese methods of the first kind, which are of particular interest, I begin with that of the most famous Japanese mathematician, Kowa Seki (1642–1708). Let $2y_0$ be the chord of the arc x of the circle of radius 1. The arc being subsequently divided into halves, let $2y_a$ be the chord of the arc $\frac{x}{2^a}$. Then we have

$$4y_a^2(1-y_a^2)=y_{a-1}^2.$$

Seki possessed a method of developing the root

$$y_a^2 = \tfrac{1}{2}(1 - \sqrt{1 - y_{a-1}^2})$$

of this equation in series of powers of y_{a-1}^2. He got, by a very curious recurring algorithm, quite after the Far-Eastern manner of reckoning, which I have not the time to explain in this place, one member of the series after another up to the sixth. It is a highly astonishing fact that Seki obtained by this method, from the equation

$$y_1^2 = \tfrac{1}{2}(1 - \sqrt{1 - y_0^2}),$$

the infinite binomial series for the exponent $\frac{1}{2}$. Then, making use of the series for y_1^2, he derived in the same manner y_2^2, by means of the equation

$$y_2^2 = \tfrac{1}{2}(1 - \sqrt{1 - y_1^2}),$$

in a series of powers, not of y_1^2, but of y_0^2. Continuing in this way, he obtained for y_3^2, y_4^2, . . . up to y_{10}^2, series of powers of y_0^2. By passing to the limit $a = \infty$, according to the formulas

$$2^{2a+2} y_a^2 = \left(2^{a+1} \sin \frac{x}{2^{a+1}}\right)^2 = x^2 = (2 \text{ arc sin } y_0)^2,$$

Seki finds the series

$$(\text{arc sin } y)^2 = \sum_0^\infty \beta \frac{1}{\beta+1} \frac{2 \,.\, 4 \,.\, 6 \ldots 2\beta}{1 \,.\, 3 \,.\, 5 \ldots (2\beta+1)} y^{2\beta+2}.$$

The laws of the coefficients of all series are found by incomplete induction, which played a great part in Japanese mathematics; but it must be stated, with great astonishment and admiration for Seki's skill and sagacity, that he, though proceeding on lines not quite legitimate, always arrives at right results. But we must allow a good deal for the non-existence of any researches concerning the validity of series in the ancient Japanese mathematics.

Putting in Seki's series $x = \frac{\pi}{2}, \frac{\pi}{3}, \frac{\pi}{4}$, special values of π^2 are obtained; on one of these values rests the formerly quoted common fraction for this quantity.

Afterwards some other series were deduced by which not π^2, but π itself, could be calculated. All these series are connected with the name of Naomaru Ajima (1737–1797 nearly). The vehicle of these researches is a very singular method, called the 'circle principle.' In our mode of expression this principle is the following. If the integral

$$\int_0^y f(y)\, dy$$

is to be calculated, $f(y)$ is developed in powers of y, thus:—

$$f(y) = \sum_0^\infty \beta \frac{f^{(\beta)}(0)}{1 \,.\, 2 \,.\, 3 \ldots \beta} y^\beta,$$

and the integral is replaced by a sum of a great number of terms, determined by the upper limit $y = \frac{p}{n}$, and the equidistant values

$$y = \frac{a}{n}, \quad a = 0, 1, 2, 3, \ldots p, \quad dy = \frac{1}{n},$$

—n being a very great number—are used to give the equation

$$\int_0^y f(y)dy = \frac{1}{n} \sum^p a \sum_0^\infty \beta \frac{f^{(\beta)}(0)}{1 \,.\, 2 \,.\, 3 \ldots \beta} \left(\frac{a}{n}\right).$$

Now the formula

$$\lim.\left(\frac{1}{n}\sum_{0}^{\infty} a\left(\frac{a}{n}\right)^{\beta}\right)_{n=\infty}=\frac{1}{\beta+1}\left(\frac{p}{n}\right)^{\beta}=\frac{1}{\beta+1}y^{\beta+}$$

was known to the Japanese mathematicians, and by making use of it they obtained

$$\int^{y} f(y)dy=\sum^{\infty}\beta\frac{f^{(\beta)}{}_{(0)}}{1.2.3..(\beta+1)}y^{\beta+1}.$$

In ancient Japanese mathematics only the two functions $f(y)=\sqrt{1-y^2}$ and $f(y)=\frac{1}{\sqrt{1-y^2}}$ were considered; that is to say, the series of the binomial theorem for the exponents $+\frac{1}{2}$ and $-\frac{1}{2}$. We are informed of three different series connected with Ajima's name, and obtained by means of the method described from a quite elementary consideration of rectilinear figures in a circle. These series are the following ones:—

$$\text{(i.) Arc sin } y = \sum_{0}^{\infty}\beta\frac{1}{2\beta+1}\frac{1.3.5....(2\beta-1)}{2.4.6....\ 2\beta}y^{2\beta+1},$$

$$\text{(ii.) } \tfrac{1}{2}(\text{arc sin } y - y\sqrt{1-y^2}) = \sum_{0}^{\infty}\beta\frac{1}{2\beta+3}\frac{1.3.5....(2\beta-1)}{2.4.6....2\beta}y^{+3^2\beta},$$

$$\text{(iii.) Arc sin } y = \sqrt{1-y^2}\sum_{0}^{\infty}\beta\frac{2.4.6....2\beta}{1.3.5....(2\beta+1)}y^{2\beta+1}.$$

The third equation would by an integration lead back to the Seki series, but I did not find any indication as to whether this reduction had been the aim of Ajima's remarkable transformation.

From all three series, special values of π can be derived; and we know that the value correct to 51 places had been calculated in 1739 by putting in the first series $y=\frac{1}{2}$. Concerning those very accurate common fractions for π and π^2 which I have quoted, I have convinced myself, with astonishment, that they must have been obtained by the Japanese mathematicians by the means which we now apply for the approximate transformation of irrational numbers into common fractions—that is to say, the calculus of continued fractions. For these numbers are convergents, and even very high convergents of such fractions.

After having heard of such unexpected Japanese work, you will not be astonished at learning that Ajima treated the ellipse in the same way; that at the beginning of the nineteenth century, there existed Japanese researches on the catenary and the cycloid; and we may trust the Japanese statement, not yet proved by documents accessible to me, that Seki and his school in the seventeenth century knew the general binomial theorem, some theorems of the theory of numbers, of the theory of maximum and minimum, of determinants, of plane and spherical trigonometry, of analytical geometry, and of geodesy.

Now the question is forced upon us whether we have in the flourishing condition of Japanese mathematics, from the seventeenth century onward, an independent development of native science, or only a transformation of imported acquisitions.

We will first consider the calculus of continued fractions proved to exist in Japan about the middle of the eighteenth century. Now, this calculus had already been used by Euclid about 400 B.C. to free fractions of common divisors of the numerator and the denominator, and by applying this method to an irrational number, and by interrupting the algorithm at any step, we obtain the method of representing the fraction approximately by the convergents of a continued

fraction. Moreover, we know that already about 500 A.D. this method had been transplanted to India, and had ripened there into a beautiful method of resolving indeterminate equations. I cannot doubt that this method had already in olden times arrived in China, within the reach of a regular connection with Japan. I suppose this part of Japanese mathematics to be of Greek origin, the more because I have, to my great surprise, found in a Japanese source the ancient Greek solutions of the famous Delian problem ascribed to Plato.

By denying to the Japanese the independent discovery of the theory of continued fractions we withdraw from them only things belonging to the lower mathematics. Much more weight is to be attributed to the quoted Japanese infinite series. Now, the basis of all these Japanese researches is formed by the binomial theorem for particular, though not integral, values of the exponent. Seki, who possessed this theorem for the value $+\frac{1}{2}$ at least, but very probably for any rational value of the exponent, died in 1708 at the age of sixty-six. A more precise dating of his work is not possible, but we can surely suppose that he knew the basis of his researches, which he taught to his scholars, already a considerable time before the year 1700. In the Occident this theorem, one of the most important parts of mathematics in general, was actually discovered by Isaac Newton in 1666. The theorem was not published till 1685, by John Wallis, and only in 1704 by Newton himself. The near coincidence of the times when the binomial theorem was known in the Occident and the Far-East excludes, with a high probability, any connection between the two discoveries, if we take into consideration the slow rate of intercourse even between European scholars, the great distance between the two opposite parts of the earth, not to be overcome in much less than three years, the difficulty of the languages and of the accessibility of a country maintained in tho e times in the uttermost seclusion by laws of the highest severity. But we can go far beyond mere probability by comparing Seki's and Newton's methods for the development of the root of a binomial. These methods both represent the analytical investigation of the numerical operations known formerly in both regions of the world; but the Eastern is as far different from the Western as things Japanese generally are from ours. Moreover, we find in Seki's other sagacious and audacious performances, for which any prototype in the Occidental sciences is entirely lacking, the revelation of a high mathematical genius, to whom the independent detection of the binomial theorem must without any hesitation be attributed.

Whereas it is merely in the highest degree probable that Seki found the binomial theorem independently, the independence of his series for $(\text{arc sin } y)^2$ is raised above any doubt by the mere fact that this series was first published in the Occident in 1815, though we are now acquainted with the fact that a letter of Leonard Euler, of the year 1737, unpublished up to the year 1904, contains this series, but here, too, only about thirty years after Seki's death.

So clear a result cannot be arrived at with respect to the question whether the three series which come down to us under the name of Ajima, living about 1760, are to be ascribed to native skill. This question is important, far beyond the special results, from the fact that the method applied—that is to say, the circle principle—is a method of the infinitesimal calculus; the particular meaning of the question being, therefore: Had the Japanese independently discovered the elements of this calculus?

At first sight the appearance is entirely against the independence of the Japanese work, since two of the three series under consideration had been published in Europe in 1685, by John Wallis, and, what is of high importance, had been derived by him in very much the same manner as in Japan. But there are several indications which point the opposite way.

The first of the three series was certainly known in Japan about 1739, and very probably much before 1722; by this fact the authorship of this series is withdrawn from Ajima, who was born about 1737. Owing to the remark of a Japanese source, that Ajima has been a disciple of a mathematician of Seki's school, I had been induced to suppose Seki himself to be the author of this series; and I am disposed to do so the more because the traces of the circle principle,

too, lead back to this mathematician. We can safely rely upon this fact, the more because we know that a generalisation of this principle from two to three dimensions, on which reposes the already mentioned second kind of Japanese computations of the number π, had been developed in Japan from 1627 onward, whereas the distinct traces of this method in the Occident cannot be found before 1658. It may be that the circle principle rests, both in the Occident and in the Far-East, on the researches of Archimedes; for there the geometrical sources may be found from which, after the lapse of centuries, the analytical method of the circle principle may have flowed independently in both regions.

If, indeed, Seki was in possession of the circle principle, considering his mathematical genius, the omission (more than the existence of the series) would require explanation. Another fact which speaks in favour of the independence of the Japanese results is that the third and most interesting of Ajima's series, though found in the Occident by Euler already in Ajima's lifetime, seems to be an undoubted property of the Japanese, since the mode of derivation is quite different from that applied to the same purpose by Euler in the years 1755 and 1768. As one more mark of independence may be mentioned the fact that, of the various series for arc tan$y$ in powers of y, by which the Occident from the year 1671 onward has supplied a much more powerful tool for the determination of the numerical value of π, no trace can be found in Japan, though the work by John Wallis of 1685, which formerly might be suspected of being the source of the first two Japanese series, contains the chief formula of this kind too.

We may add, finally, that the startling similarity, notwithstanding the independence of the advances made by different persons in different countries nearly at the same time, has been often pointed out in the history of science. I call to your mind the invention of the infinitesimal calculus and of the non-Euclidean geometry.

As a result of these considerations, I conclude that the invention and application of the elements of the infinitesimal calculus may be ascribed to the Japanese mathematicians, though not with certainty, yet with a sensible degree of probability. Only from the beginning of the nineteenth century I consider can distinct traces of direct influence of Occidental on Far-Eastern mathematics be traced.

In following the development of Japanese mathematics we meet with the surprising fact that to the tide-like advance of mathematics in Japan from the second half of the seventeenth century onwards, nearly equivalent in the importance of its results to contemporary Occidental mathematics, there corresponds no activity to be compared to that which existed in the Occident in the eighteenth century, led by the incomparable Leonard Euler.

The concession of independent work to the old Japanese mathematicians does not exclude every Occidental—though indirect—influence. On the contrary, since the time of blossoming of the Japanese mathematics coincided with an active state of Dutch trade, which in 1609 introduced the fruits of Occidental civilisation into Japan, it must be regarded as highly probable that this connection called to life the slumbering inclination to the mathematics and paved the way for its development.

I conclude these remarks with the affirmation that the Japanese have revealed by their own efforts in the arts, as has been long known, by their own productivity in the mathematics, as we have just now seen, and probably by performances in other domains, not yet accessible to foreign investigation, capabilities quite comparable to our own. And we are entitled to conclude that Japan will in future, with the highest success, play her part in the eternal work of civilisation common to all nations, independently of casual political conjunctures which the day creates and the day destroys.

THURSDAY, AUGUST 17.

The following Papers were read :—

1. *On Star Streaming. By* Professor J. C. KAPTEYN.—See Reports, p. 257.

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2. *The Magnetic Survey of South Africa. By* Professors J. C. BEATTIE *and* J. T. MORRISON.

A survey of South Africa was started by Professors Beattie and Morrison in the summer of 1897–1898.

The observational work has been carried on since that time whenever opportunity offered; naturally it was greatly interfered with by the war. Soon after the declaration of peace the various South African Governments each contributed to a fund for paying the expenses of a field party for a year's continuous work. This party observed during the whole of 1903 and part of 1904.

Financial assistance has also been received from the Government Grant Committee of the Royal Society.

The necessary observations have been made at about 400 stations, distributed chiefly along the various railways in Cape Colony, Rhodesia, the Transvaal, the Orange River Colony, and Natal, in the south of Cape Colony, the east of the Transvaal, the Basutoland border, and the north-west of Cape Colony.

Observations have been repeated at twenty widely separated stations for the purpose of determining the secular variations of the elements.

The annual and the daily observations have been derived from the earlier work of Sabine in South Africa.

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3. *The Radio-activity of Ordinary Matter.*[1] *By* A. WOOD, *B.A., B.Sc.*

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4. *Thermal Radiation at Very Low Temperatures. By* J. T. BOTTOMLEY, *LL.D., D.Sc., F.R.S.*

The experiments described in this paper form part of an investigation on which the author has been engaged for some time past. The object of this investigation is the direct determination, in absolute measure, of the loss of energy from a heated body to cooler surroundings under differing circumstances as to (1) the dimensions of the cooling body; (2) the state of the surfaces of the cooling body and of the containing envelope; and (3) the mean absolute temperatures of the cooling body and the envelope. Several papers have already been published by the author on this subject, some of them communicated to Section A of the British Association; and when, through the extreme kindness of Lord Blythswood, an unlimited supply of liquid air was placed at the author's disposal, to be followed by a supply of liquid hydrogen, it seemed most desirable to extend the research in the direction indicated, and to determine, in absolute measure, the radiation, under given circumstances, from a body at, say, ordinary atmospheric temperature, to an enclosure at a temperature which may perhaps approximate to that of space. So far as is known to the author nothing of this kind has hitherto been attempted.

The following is a general description of the apparatus used. At the centre of a hollow sphere of copper, the interior surface of which has been coated with a

[1] See *Philosophical Magazine*, ix. 1905, p. 550.

thin covering of fine-grained lampblack, a copper globe, from which the radiation takes place, is suspended. The copper globe is 5 centimètres in diameter, while the diameter of the envelope is 10 centimètres. In the experiments carried out at low temperatures up to the present the surface of the hanging globe has been either coated with a very fine covering of lampblack, or else silvered electrolytically and polished to the highest degree attainable. The polish is very much better than even the mirrored surface obtained by silversmiths, and, as formerly shown, the degree of polish makes a very great difference to the result.

The enclosing copper envelope is connected to a pair of five fall Sprengel pumps, and the following results have been obtained at pressures[1] not greater than 0·1 m. or 0·2 m. (one-tenth or two-tenths of a millionth of an atmosphere).

When the vacuum is complete the enclosure is cooled down by the application around it of a bath of liquid air, contained in a Dewar double-walled vessel. Under these circumstances the suspended globe, which at the beginning is at the general temperature of the laboratory, cools by radiation. The cooling process is carried on for some hours; and during the earlier part of this time the difference of temperatures of the cooling globe and the enclosure is read off by means of a pair of thermo-electric junctions, one of which is at the centre of the globe[2] and the other immersed in the liquid-air bath. The readings are taken by means of a suitable moving coil galvanometer, at equal intervals of time, given by a chronometer which beats half-seconds.[3]

When the temperature of the globe has been reduced nearly to the temperature of the surroundings—that is, nearly to the temperature of the liquid-air bath, a process which, with the high vacuum mentioned occupies, as has been said, many hours—the conditions are reversed. The liquid air surrounding the outer envelope is replaced by hot water, or hot oil, and the hanging globe begins to receive heat, by radiation, from the surrounding walls. The reading of the galvanometer, connected with the thermo-electric couple, taken at equal intervals of time, gives once more the difference of temperature between the globe and the surrounding envelope.

From the readings thus taken the rate of cooling, or the rate of heating, of the globe is calculated; and, finally, the absolute loss (or gain) of heat per unit of cooling surface, per unit difference of temperatures of cooling surface and surroundings, per unit of time, is obtained.

The method of standardising the thermo-junction need not be discussed in this abstract, although it is not devoid of interest. It was explained fully in the paper. Neither is it necessary to go at length into details of the calculations. It will be sufficient here to give the results of the experiments, remarking at the same time that the work is by no means concluded.

In a paper communicated to the Royal Society in 1893, and published in the 'Philosophical Transactions,' the results are given of experiments carried out in an exactly similar way to that described above. The same copper globes were used as the cooling bodies, and the same spherical shell as the envelope. The only practical difference between those experiments and these now described is that the latter were carried out at the lowest temperatures the author could reach, and the former at the highest. The latter are near the temperature of liquid air, and the earlier at some three or four hundred degrees higher in the scale. The results of the two series of experiments are thus exactly comparable.

[1] It is difficult to maintain these extremely low pressures. The application of the intense cold of the liquid air to the copper shells, which constitute the enclosure, causes them to warp, and develops frequently an excessively minute leak, which causes a very slight rise of pressure. This curious phenomenon needs investigation.

[2] Many important details of similar experiments are given in a paper communicated some years ago to the Royal Society's *Philosophical Transactions.*

[3] It has been shown in previous papers that the difference of temperatures (under present circumstances) between the centre of the cooling globe and the surface is so small that it may be neglected, and, this being the case, it is obviously better to put the junction at the centre of the globe than at any other point of it.

The following tables give some of the results obtained :—

Copper Globe Thinly Sooted.

April 8, 1890			May 31, 1905		
Pressure $\frac{1}{5 \cdot 1}$ m.			Pressure 5·8 m. (somewhat variable)		
Absolute Temperature of Cooling Globe	Excess of Temperature of Cooling Globe above Temperature of Surroundings	Emissivity, or Loss of Heat per sq. cm. per second per 1° C. of Excess	Absolute Temperature of Cooling Globe	Excess of Temperature of Cooling Globe above Temperature of Surroundings	Emissivity, or Loss of Heat per sq. cm. per second per 1° C. of Excess
° 505·5	° 217·5	° $2 \cdot 23 \times 10^{-4}$	° 246·4	° 165·4	° $9 \cdot 57 \times 10^{-5}$
482·3	194·3	2·00 ,,	222·4	141·4	9·17
468·1	168·1	1·78	206·1	125·1	8 78
433·9	145·9	1·63	193·6	112·6	8·38
422·1	134·1	1·52	183·3	102·3	7·99
411·9	123·9	1·44	174·6	93 6	7·59
402·8	114·8	1·42	167·3	86·3	7·20
394·6	106·6	1·36	160·2	79·2	6·80
387·4	99·4	1·27	151·8	70·8	6·21
380·9	92·9	1·29	144·3	63·3	5 61
374·9	86·9	1·20	137·8	56·8	5·63
369 4	81·45	1·22	132·5	51·5	5·64
355·1	67·1	1·15			
351·2	63·2	1·07			

Copper Globe Silvered and Highly Polished.

April 14, 1890			July 20, 1905		
Pressure at Commencement 10 m. to 12 m., coming down rapidly to less than $\frac{1}{10}$ m.			Pressure 0·1 m.		
Absolute Temperature of Cooling Globe	Excess of Temperature of Cooling Globe above Temperature of Surroundings	Emissivity, or Loss of Heat per sq. cm. per second per 1° C. of Excess	Absolute Temperature of Cooling Globe	Excess of Temperature of Cooling Globe above Temperature of Surroundings	Emissivity, or Loss of Heat per sq. cm. per second per 1° C. of Excess
° 526·5	° 240·5	° $5 \cdot 58 \times 10^{-5}$	° 290·0	° 211·0 C.	° $4 \cdot 502 \times 10^{-6}$
519·4	233·4	5·10 ,,	287·5	208·5	4·47 ,,
513·2	227·2	4·06 ,,	285·1	206·1	4·45 ,,
508·3	222·3	3·07 ,,	282·7	203·7	4·42
501·7	218·7	2·68 ,,	280·4	201·4	4·39
497·4	211·4	2·64 ,,	278·2	199·2	4·36
494·4	208·4	2·55	276·0	197·0	4·34
491·7	205·7	2·59	273·8	194·8	4·31
488 9	202·9	2·59	271·8	192·8	4·28
484·2	198·2	2·16	269·7	190·7	4·25
481·9	195·9	2·25	267·8	188·8	4·23
479·6	193·6	1·95	265·9	186·9	4·20
477·5	191·5	1 64	264·1	185·1	4·17
473·7	187·7	1·73	263·2	184·2	4·16
469·9	183·9	1·86	261·5	182·5	4 13
465·9	179·9	1·77	260 0	181·0	4·01
462·6	176·6	1·90			
460·9	174·9	1·90			
453·9	167·9	1·92			

5. *A Simple Form of Gas Thermometer.* *By* J. T. Bottomley, *LL.D., D.Sc., F.R.S.*

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6. *The Diminution of Entropy according to the Kinetic Theory of Gases.* *By* S. H. Burbury, *F.R.S.*

If the motion of the several parts of a material system are dynamically reversible, is it possible for the motion of the aggregate to be irreversible? Many authorities will answer Yes, relying on Boltzmann's H theorem as a classical instance. According to that theorem, H, a function of the molecular velocities, necessarily diminishes until a certain condition (Maxwell's law) is attained, and is then minimum.

The proof rests on *the assumption of independence*—that is, that the chance of any molecule having assigned velocities is independent of the velocities and positions of all the other molecules for the time being.

To this theorem the objection is made: If, when in this process H has become minimum, all the velocities were reversed, the system must, by the continuity of the motion, retrace its course, passing through all the states of the original course in the reverse order, with H increasing. This is contrary to the theorem.

The accepted explanation of the paradox is that the reverse course, though possible, is very improbable. This virtually admits irreversibility. And the theory is widely accepted that increase or diminution of entropy is a question only of greater or less probability.

But now, H being minimum, consider two states of the system: state A, in which the velocities are $u_1 \ldots u_n$, and B, in which, *cæteris paribus,* they are $-u_1 \ldots -u_n$. If A is the end of a course of diminishing H, B is the beginning of a reversed course of increasing H. But (1) we cannot give any plausible reason why B or A should be the more probable, except the *petitio principii* that the one which leads to increase of H is the less probable.

(2) According to Maxwell's law, which is supposed to prevail, A and B are equally probable. With great reluctance to differ from high authorities, I think that the orthodox explanation, with all its consequences, is erroneous.

We have obtained for the system first one and then the other of two inconsistent results, because we have ascribed to the system first one and then the other of two inconsistent properties. Assuming the condition of independence, we prove that H diminishes. Assuming the continuity of the motion, we prove that for every course in which it diminishes there is one in which it increases. The conclusion is that the condition of independence is inconsistent with continuity of the motion, and ought to be abandoned altogether.

The physical result is, I think, this: When H is near its minimum $\frac{dH}{dt}$ is extremely small. When H differs much from its minimum $\frac{dH}{dt}$ is generally great. H will be on average of time generally near its minimum, subject to short excursions into higher values. In the meantime, to any natural system disturbances frequently happen. The improbability consists, not in $\frac{dH}{dt}$ being positive, but in the system remaining undisturbed sufficiently long for H to attain sensibly higher value. There is nothing irreversible about the matter.

The diffusion of gases, a process apparently irreversible, can be treated in an analogous manner.

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7. *The Daily Variation of the Northerly* (X) *and the Easterly* (Y) *Components of the Magnetic Intensity at Capetown, St. Helena, and Mauritius.* *By* Professor J. C. Beattie, *D.Sc.*

From Sabine's results, published in the volumes of the Magnetical and Meteorological Observations for the Cape of Good Hope and for St. Helena, and for Mauritius ('Magnetical Observations,' 1875–1897, by T. F. Claxton), the daily

variations of X and of Y are calculated and tabulated for each hour of the day for the different months of the year. These are then combined into four periods—March-April, May-August, September-October, and November-February.

The values of the latitudes of these three stations are added and divided by three, and the same is done for the longitudes; this gives the latitude and the longitude of a mean station whose daily variations of X and of Y at any hour are obtained by taking the algebraic mean of the variations at the three stations at the same hour.

The latitude and the longitude of the three stations relative to the mean station are then obtained, and the variations at any station for a particular hour expressed in an equation

$$\Delta X_s = \Delta X_m + f\,(\text{lat.}_{sm}) + g\,(\text{long.}_{sm})$$

where ΔX_s is the variation of X at a particular hour of Greenwich mean time at any station,

ΔX_m is the variation of X at the same hour of Greenwich mean time at the mean station.

$f\,(\text{lat.}_{sm})$ is a function of the latitude of the station with respect to the mean station.

$f\,(\text{long.}_{sm})$ is a function of the relative longitude of the same station with respect to the mean station.

The values of ΔX and of ΔY are then obtained at the intersection of alternate degrees of latitude and of longitude.

The integral

$$\int H ds$$

taken round a closed curve then gives the value of the vertical current perpendicular to the enclosed area, which would account for the variations of the X and the Y as they are given by the interpolation formula.

The value of this current is tabulated for each hour of the day, and the results shown in maps.

FRIDAY, AUGUST 18.

The following Papers were read:—

1. *Geodetic and Gravitational Observations in Spitzbergen.* *By* Dr. O. Backlund.

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2. *On the Theory of Algol Variables.*[1] *By* J. H. Jeans.

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3. *Double Star Astronomy in the Southern Hemisphere.* *By* R. T. A. Innes, *F.R.S.E.*

This paper briefly recapitulated the work done in the past in the discovery and measurement of double stars in the Southern Hemisphere. The systematic double star survey of the Northern Hemisphere and that portion of the Southern visible from California, now being carried on at the Lick Observatory by Professors Aitken and Hussey, was referred to. The desirability of providing a telescope of 24 or 25 inches aperture to continue this survey to the South Pole was pointed out.

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[1] See *Astrophysical Journal*, September 1905.

4. *On Lunar Radiation.* *By the* Earl of Rosse, *K.P., F.R.S.*

In this paper the author, after recapitulating briefly the leading points and results of determinations of lunar radiation made at different ages of the moon, more fully described in 'Proc. Roy. Soc.' 1869 and 1870, and 'Phil. Trans.' 1873, also of measurements of heat during lunar eclipses (see 'Trans. Roy. Dublin Soc.' 1885 and 1891), made some suggestions for future work with specially made, but simple and cheap, apparatus, also for prosecuting the inquiry in better climates than that of the United Kingdom.

He further suggested co-operation between workers at widely different latitudes and longitudes, so that every eclipse, whether occurring during the northern winter or southern winter season, may be equally well observed, during the whole of its progress, under equally favourable conditions, at one or other of the stations.

He also discussed different modifications both of the heat-collecting and heat-detecting appliances.

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5. *A New Instrument for Measuring Stellar Photographs.* *By* Arthur A. Rambaut, *M.A., D.Sc., F.R.S.*

The instrument recently constructed by Sir Howard Grubb, F.R.S., for the Radcliffe Observatory, Oxford, which is the subject of this note, is designed for the purpose of measuring, with all available precision, the position of a star-image with regard to the réseau square within which it falls, the réseau being impressed photographically on the plate in the usual way before development. In what follows this réseau is referred to as the 'black' réseau.

Externally the instrument somewhat resembles that constructed by Messrs. Repsold for the Cape Observatory, and described by Sir David Gill in the 'Monthly Notices' R.A.S., vol. lix., No. 2. It differs, however, from the latter in many essential details.

The base of the instrument is a massive iron casting, the plane top of which is inclined at an angle of 45° to the horizon. The photographic plate is carried, as in the Cape instrument, on two slides running on two mutually perpendicular steel cylinders. The movement of the slide is in each case effected by means of a rack and pinion, and each cylinder has attached to it a scale divided to 5 mm., and numbered to correspond with the réseau lines on the plate. An adjustment is provided by which the réseau lines may be placed with great delicacy exactly parallel to the axes of the cylinders. The instrument will measure plates up to 12 inches square.

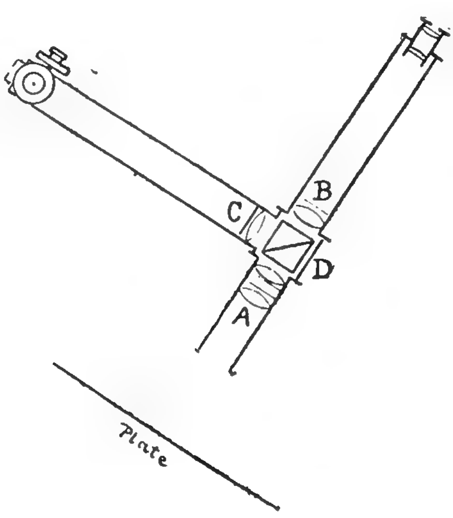
The microscope, which is of a novel construction, is carried by a strong cast-iron tribrach, supported on pillars, as in the Cape instrument. It consists of a central cube, D, into three sides of which are screwed brass tubes carrying three objectives, A, B, and C. At the centre is fixed a cube of glass composed of two parts, each of which is a right-angled prism. The face opposite the right angle of one of these prisms is coated by a special process with a thin film of galena, and the two prisms are then cemented together so as to form a cube. The two objectives, A and B, together form a doublet lens, the light from any point of the plate passing from one to the other in a parallel beam. Any colour effect due to refraction at the surfaces of the cube is thus avoided.

In the focal plane of the objective C is a small réseau ruled on a silvered glass plate, which is movable on slides at right angles to each other by means of micrometer screws. The objectives B and C together also form a doublet lens, the light being reflected as a parallel beam from the galena surface. The small réseau is thus seen projected on the plate, and, as the lines appear bright, it is convenient to refer to it as the 'white' réseau. There are adjustments for setting the slides parallel to the lines of the réseau and for setting the micrometer as a whole, so that, as seen in the eyepiece, either system of lines in the white réseau may appear exactly parallel to the corresponding system in the black réseau.

The white réseau contains sixteen lines in each direction (fifteen spaces), the outer lines forming a square which just fills one of the squares of the black réseau. Since a black réseau interval (5 mm.) corresponds to an angle of 150″ in the Radcliffe telescope, it follows that a white réseau interval is equal to 10″. The pitch of the micrometer screws is equal to one white réseau interval, *i.e.* 10″, and the heads being divided into 100 parts, which are read by estimation to tenths, a unit in the last figure is equivalent to 0″·01.

The eyepiece is carried on two slides at right angles to each other, so that any object can be brought rapidly into the centre of the field of view.

When a plate is inserted in the machine the preliminary adjustments of focussing, bringing the lines of the black réseau parallel to the slides, and those of the two réseaux into sensible parallelism, can be effected in two or three minutes by means of the adjusting screws provided for that purpose. These adjustments having been satisfactorily completed, the observations for measuring the position of a star-image with regard to the réseau square in which it lies are as follow: By means of the racks the black réseau is set so as to coincide approximately with the white. Using the micrometer screws three corners of the white réseau are then brought in succession to coincide *exactly* with the corresponding corners of



the black réseau. As the white lines are considerably thinner than the black, and appear neat and sharp when projected on the somewhat softer black lines, this is an observation which can be made with very great delicacy. From a large number of observations the probable error of a single setting of this sort was found to be $\pm 0^{r}\cdot002 = \pm 0''\cdot02$.

The corners of the square being numbered in rotation 0, 1, 2, 3, beginning at the left-hand bottom corner and going round in an anti-clockwise direction, three pairs of readings of the horizontal and vertical micrometer screws are taken corresponding to the corners 0, 1, and 3, which may be denoted by h_0, v_0; h_1, v_1; h_3, v_3, respectively. If the star-image lies between the mth and $(m+1)$th vertical lines, and between the nth and $(n+1)$th horizontal lines, the intersection of the mth and nth lines is made, by means of the micrometer screws, to coincide with the centre of the star-image, and the readings h and v of the two screws are taken. If, then, we take as unit the fifteenth part of a black réseau interval (10″ approximately), and if the values of the micrometer screws are $1-p$ and $1-q$ respectively, when expressed in terms of a white réseau interval (so that p and q are very small quantities), and if we put

$$\xi = m + h - h_0 \text{ and } \eta = n + v - v_0,$$

the coordinates of the star-image referred to the black réseau may be represented by the following simple expressions:—

$$\left.\begin{aligned} x &= \xi - p(h-h_0) - \frac{h_1-h_0}{15}\cdot\xi - \frac{h_3-h_0}{15}\cdot\eta \\ \text{and}\qquad y &= \eta - q(v-v_0) - \frac{v_1-v_0}{15}\cdot\xi - \frac{v_3-v_0}{15}\cdot\eta \end{aligned}\right\} \quad . \quad . \quad . \quad (a)$$

where the numerical value of the quantities ξ and η cannot in any case exceed 15. Also $h-h_0$, $v-v_0$ will always be less than unity, and none of the quantities p, q, h_1-h_0, v_1-v_0, h_3-h_0, and v_3-v_0 will ordinarily exceed more than a few units in the third place of decimals. The reduction is therefore of a very simple character. These formulæ take account of the 'run' of the screws, a possible error of inclination of the two systems of lines, a possible inequality between the horizontal and vertical scales of the white réseau, and an inequality in size between the black and the white réseau squares. They do not correct for errors of division of either réseau nor for a possible error of inclination in the lines of the black réseau. Errors of division, if sensible, must in all cases be applied separately to the original measures. The errors of division of the white réseau do not affect the readings h_0, v_0; h_1, v_1; nor h_3, v_3, since we are of course at liberty, when determining them, to make the errors of the extreme lines zero. But they do affect h and v. They may, however, be very simply tabulated with m or n as argument. On the other hand, if the errors of the black réseau are sensible they must be applied to the readings h_0, v_0, &c., and with these corrections our measures will then be referred to an ideally perfect réseau.

In the method of measurement here described the following advantages are claimed:—

(1) No absolute perfection nor constancy in the adjustments is postulated. If the lines of the black and the white réseaux are not absolutely parallel, or if the two squares are not exactly the same size, the errors thus introduced are completely corrected by the third and fourth terms on the right of equation (a).

(2) The sharp bright lines of the white réseau can be set with remarkable accuracy on the black réseau lines or the black star-images.

(3) The measures are referred to the intersections only of the lines of the black réseau. This has the double advantage that these are the very points for which the errors of the réseau are determined, and that when these intersections only are required the rest of the réseau might, if desired, be completely masked out in printing.

(4) The principal advantage, however, lies in the reduction which is effected in the number of settings when more than one star-image falls within a réseau square. With a simple eyepiece scale subdivided by micrometer screws, as employed at Cambridge and other places, six settings are the minimum required to determine the position of each individual star-image. Thus, if there are fifty stars within the square, at least 300 settings must be made. In the same case, with the Oxford instrument, only 106 are required. The enormous advantage thus gained in measuring plates with large numbers of stars upon them is obvious. Plates of the size used in the astrographic survey contain 900 réseau squares. A rich plate may easily afford 9,000 stars, or, on the average, ten per square. To determine the position of each of these without duplicating any of the measures would, with the Cambridge type of instrument, entail 900 × 60 = 54,000 settings. With the Radcliffe measuring instrument we should require only 900 × 26 = 23,400, a reduction of 30,600 settings, or 57 per cent. of the whole!

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6. *Note on Professor Kapteyn's Method of Determining Stellar Parallax by Means of Photography.* By ARTHUR A. RAMBAUT, *M.A.*, *D.Sc.*, *F.R.S.*

Professor Kapteyn's method is described in Part I. of the publications of the Astronomical Laboratory of Gröningen. Instead of exposing the *same* plate at or near three successive epochs of maximum parallactic displacement, as Kapteyn requires, it is proposed in this paper to take three different negatives, which may be developed in the ordinary course as soon as convenient after exposure. From each of these negatives a positive is printed, and these three positives are transferred again to a single final negative.

In order to determine the probable error introduced by this double photographic reproduction, two plates were compared, each containing a triple photograph of a group of stars. In one case the plate was exposed in the telescope three times, in rapid succession, to the same region of the sky, the telescope being slightly displaced between each exposure. In the other a negative was taken, and from this three separate positives were made, which were afterwards transferred to a single plate. The probable error of a single measure of the distance between two images of the same star is found to be practically the same for both plates. This result indicates that, so far as these observations go, the probable error arising from the process of photographic reproduction is practically equal to the probable error in the position of a star image due to coarseness or irregularities in the film.

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7. *A Comparison of the Long-period Rainfall Records at Cape Town and Greenwich.* By HUGH ROBERT MILL, *D.Sc.*

A cursory examination of the records of annual rainfall kept from 1841 to 1904 at the Royal Observatory, Cape Town, and the Royal Observatory, Greenwich, shows a general similarity in the recurrence of series of wet and dry years, not corresponding to definite cycles, but occurring in irregular spells of variable length, separated by unequal intervals. The total annual rainfall at the two stations does not differ greatly, but the range is greater for the Cape Observatory than for Greenwich, as shown in the following table:—

—	Cape	Greenwich	Cape	Greenwich
	in.	in.	%	%
A. Mean	25·94	24·14	100	100
B. Wettest year	41·03	35·54	158	147
C. Driest "	17·07	16·38	66	68
D. Wettest three consecutive years	34·42	30·01	133	124
E. Driest " " "	18·94	20·71	73	86
Difference B–C.	23·96	19·16	92	79
" D–E.	15·48	9·30	60	38

On a curve smoothed by taking the mean of three consecutive years, and plotting it on the place of the central year, it is seen that the wet spell 1858–1862 and the dry spell 1894–1901 were common to both, but that in almost all other cases a wet spell in the Cape peninsula corresponded to a dry spell in London, and *vice versa*. There was no apparent recurrence at regular intervals, and the remarkable flatness of the Greenwich curve during recent years had no analogy in the Cape curve.

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8. *The Effect of the Sun-spot Period on the Daily Variation of the Magnetic Elements at the Cape of Good Hope.* By G. H. FINCHAM, *B.A.*

Sabine's results at the Cape of Good Hope for each of the years 1842–1847 for declination, horizontal intensity, and vertical intensity have been used to determine the daily variations in absolute units.

The variation is then assumed to depend linearly on the number of sun-spots, and the following equation used to separate that part depending on the sun-spots from the other or normal part:—

$$a = a_1 + \nu a_2$$

where a is the total daily variation
a_1 is the normal daily variation
ν a constant proportional to the spotted surface of the sun:
a_2 the daily variation due to the sun-spots.

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9. *Can the Earth's Motion through Æther affect Material Phenomena?* *By* Professor J. Larmor, *Sec. R.S.*

JOHANNESBURG.

TUESDAY, AUGUST 29.

The following Papers were read:—

1. *The Origin and Progress of Geodetic Survey in South Africa, and of the African Arc of Meridian.* *By* Sir David Gill, *K.C.B., F.R.S.*—See Reports, p. 228.

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2. *On Winding Ropes in Mines.* *By* Professor John Perry, *F.R.S.*

When a cage is descending, and the upper end of the rope is suddenly stopped, what occurs in the rope? And, especially, what is the tension at the upper and lower ends? The solution was given the author by Professor Love, and was extended by a pupil, Mr. Richardson, who has drawn curves for a given case, comparing the results with an approximate simple solution. These curves were exhibited. Because internal friction and yieldingness of attachments are neglected in the mathematical problem, it is probable that the simple solution is more correct in all cases where the calculation is important. Reference was made to a paper read in Section G, in which the author used the simple solution, and proposed a method of preventing accidents in mines.

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3. *On the Present State of the Lunar Theory, and on the Formation of a New Set of Lunar Tables.* *By* Professor E. W. Brown, *F.R.S.*

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4. *The Value of the Secular Acceleration of the Moon derived from the Early Eclipses of the Sun.* *By* E. Nevill.

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5. *On the Density of Matter in Space.* *By* R. T. A. Innes.

The author showed that, adopting the most probable figures for (a) the number of molecules in a cubic centimètre, (b) the number of stars and their masses, and (c) the extension of the luminiferous ether, the density is of the order of one molecule to every 800,000,000 cubic centimètres of space.

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6. *The Distances of the Nearer Fixed Stars.* *By* R. T. A. Innes.

This paper gave the distances from each other of all known stars which fall within a limit defined by a parallax of 0''·2.

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7. *A Dry Daniell Pile.* *By* J. Brown, *F.R.S.*

For the electrification of electrometer needles and similar purposes it seemed that a constant dry pile would be useful. To test such a pile, constructed on Daniell's principle, sheets of commercial zinc and copper 9 in. square were coated on one side with sheets of twilled cotton fabric (as used for glass cloths) wet with hot 10-per-cent. solutions respectively of zinc sulphate and copper sulphate. When dry these were built up in the appropriate way with a sheet of plain blotting paper between each pair of coatings, to represent the usual porous diaphragm, and the whole compressed in a screw press between rubber sheets as insulators.

When built (February 1903) the E.M.F. was 1 Daniell per cell or rather more. It then dropped to a steady, though lower, value for 2½ years, registering 0·95 to 0·9 Daniell till July last, when it was 0·9. Thereupon, on dismounting the pile for examination, it appeared to be unchanged, and on reforming it the same voltage was given, 0·9. After short-circuiting, the pile recovered its E.M.F. immediately. Of course, a very minute current only passes in a pile of this kind, the resistance being so very high.

A smaller pile, 4 in. by 4 in. sheets—similar in other respects, except that the cotton sheets were, the author believed, dried before placing on the metals—gave 0·7 to 0·8 Daniell at first, but 0·9 after six months. A similar pile with blotting paper instead of the cotton fabric gave a similar initial result, but was not tested further.

Another, in which the copper plate was replaced by copper deposited from copper sulphate solution on one side of the zinc, then washed and dried, gave about 0·7 Daniell.

The advantages of this pile may be considered to be its practical constancy for years, its ease of construction, and of reconstruction should it become exhausted.

WEDNESDAY, AUGUST 30.

The following Reports and Papers were read:—

1. *Report of the Seismological Committee.*—See Reports, p. 81.

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2. *Recent Advances in Seismology.* *By* John Milne, *F.R.S.*

Modern seismology may be said to date from 1880, when the Seismological Society of Japan was founded. In the twenty volumes issued by that Society will be found at least the germs of nearly all the investigations carried out since that date. Attention was first directed towards obtaining instruments which would give actual measurements of earthquake motion, with the result that 'steady points' were devised, and are now in use throughout the world. From a knowledge of the actual nature of earthquake motion derived from the use of these instruments new rules and formulæ for the use of engineers and builders have been established. In Japan and other countries these have been extensively applied in the construction of piers for bridges, tall chimneys, walls, ordinary dwellings, embankments, reservoirs, &c. Inasmuch as the new types of structures have withstood violent earth-shakings, whilst ordinary types in the neighbourhood have failed, it may be inferred that much has already been accomplished to minimise the loss of life and property.

The application of seismometry to the working of railways, particularly in Japan, has led to the localisation of faults on lines and alterations in the balancing

of locomotives. The result of the latter has been to decrease the consumption of fuel.

Later instruments were devised to record earthquake motion which cannot be felt, with the result that a person living in any one part of the world can record and obtain definite information about any *large* earthquake originating even as far off as his antipodes. These records of the unfelt movements of earthquakes indicate the time, the position, and, what is of more importance, also the cause of certain cable interruptions. The practical importance of this latter information, especially to communities who may by cable failures be suddenly isolated from the rest of the world, is evident. The many occasions that earthquake records have furnished definite information respecting disasters which have taken place in distant countries, correcting and extending telegraphic reports relating to the same, is another indication of the practical utility of seismic observations. Seismograms have frequently apprised us of sea waves and violent earthquakes in districts from which it is impossible to receive telegrams, whilst the absence of such records has frequently indicated that information in newspapers has been without foundation, or at least exaggerated. The localisation of the origins of these world-shaking earthquakes, besides indicating sub-oceanic sites of geological activity, indicates positions where the hydrographer may expect to find unusual depths. They have also shown routes to be avoided by those who lay cables.

Seismograms of unfelt movements throw light upon what have, up to recently, been regarded as unaccountable deflections in the photograms from magnetographs, barographs, and other instruments sensible to slight displacements. They have also explained unusual rates in certain timekeepers.

The most important scientific result obtained is dependent upon observations on the rate at which motion is propagated in various directions throughout the world. Until these observations had been made our knowledge respecting the interior of the earth chiefly related to its density and temperature; now we know much respecting its rigidity.

The general result of incentives which had their origin in Japan is that nearly every civilised country in the world has had its attention directed to seismology, has established seismographs, and recognises the scientific and practical importance of a new science.

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3. *Report on the Investigation of the Upper Atmosphere by Means of Kites.*

See Reports, p. 81.

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4. *Report on Meteorological Observations on Ben Nevis.*

See Reports, p. 77.

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5. *On the Teaching of Elementary Mathematics.*

By Professor JOHN PERRY, *F.R.S.*

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6. *Report on Magnetic Observations at Falmouth Observatory.*

See Reports, p. 80.

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7. *The Experimental Foundations of the Theory of Heat Conduction.*

By CHARLES H. LEES, *D.Sc.*

The author reviewed the recent experimental work which has been done on the subject of heat conduction, and showed that the weight of evidence furnished thereby is in favour of the thermal conductivities of many bodies decreasing as the temperature increases.

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8. *Meteorological Notes from Natal Observatory.* *By* R. Fermor Rendell, *B.A., F.R.A.S.*

Position of Observatory.—The Observatory is situated on the south-eastern slope of a low range of hills near Durban, about two and a half miles from the sea, and at a height of about 260 feet above the sea-level. It is in south latitude 29° 50′ 46″·7, and in east longitude 2 hours 4 min. 1·18 sec. from Greenwich.

Observations.—For full details of the meteorological records maintained at the Observatory and at various stations throughout the Colony, reference must be made to the yearly reports of the Government astronomer.

In the present paper an endeavour was made to exhibit, in as clear a form as possible, some of the important results indicated by a study of these reports.

The continuous records now being obtained are already of considerable value, and there can be no doubt that they will steadily increase in usefulness, as the period over which they extend becomes longer, especially if an advance is also made in the number and efficiency of observers working in neighbouring regions.

Rainfall.—A table was given showing the monthly results for the twenty-one years 1884–1904 inclusive. The annual totals were also shown, and, with the help of charts which have been prepared, it can readily be seen at a glance how far each month or each year is above or below the average.

A further tabular statement showed the number of days on which rain fell during each month and each year.

In addition, the total fall for each winter and each summer has been extracted, and the means have been calculated.

A supplementary table gave the results of observations made at the Botanical Gardens before the foundation of the Observatory.

The continuous record is thus carried back to the beginning of the year 1873.

Tabulated Records.—Under the heading of 'Annual Summaries,' the following results are presented in tabular form for the twenty years 1885–1904 inclusive:—

1. The monthly and annual means of the standard barometer readings taken daily at 9 A.M. and at 3 P.M.
2. Similar records of the standard thermometer readings.
3. Monthly and annual means of daily records of maximum and minimum temperature in shade.
4. The actual maximum and minimum temperature recorded in each month.
5. The mean amount of moisture in the air.
6. The average force of the wind.
7. The average amount of cloud.

Following the annual summaries will be found a condensed table to facilitate a comparison of the results for each year. By its means the character of any season can be ascertained at once.

The maximum and minimum readings of the barometer and the thermometer, and the greatest variation of temperature in one day, are shown for each year.

In most respects the tables given explain themselves; a detailed description, therefore, seems superfluous.

As an example of a typical year, a full record of the daily observations during 1903 is added. This, with the help of the analysis which follows it, shows clearly the general character of the various changes which occur in Durban during the course of a year.

Concluding Remarks.—The detailed information now available as to climatic conditions in Natal for some years past will bear upon any discussion which arises as to the development of observing stations in South Africa.

An additional importance attaches to these records, as a connection has been traced between conditions prevailing in South Africa and those in Australia.

Natal observations are also employed in the investigation of the fluctuations of rainfall in India.

9. *On the Interpretation of Signs in the Formulæ of Solid Geometry.* *By* Professor R. W. GENESE, *M.A.*

Let the unit sphere about the origin O meet the rectangular axes of reference in X, Y, Z, and let OP, OQ, OR be any three radii the co-ordinates of whose extremities are (l_1, m_1, n_1), (l_2, m_2, n_2), (l_3, m_3, n_3).

The equation to the plane OQR is

$$\begin{vmatrix} x & y & z \\ l_2, & m_2, & n_2 \\ l_3, & m_3, & n_3 \end{vmatrix} = 0$$

Hence the determinants

$$\Delta = \begin{vmatrix} l_1, & m_1, & n_1 \\ l_2, & m_2, & n_2 \\ l_3, & m_3, & n_3 \end{vmatrix} \text{ and } L_1 = \begin{vmatrix} 1 & 0 & 0 \\ l_2, & m_2, & n_2 \\ l_3, & m_3, & n_3 \end{vmatrix}$$

have the same or opposite signs according as P and X are on the same side or opposite sides of OQR.

1. Let P and X be on the same side of OQR.

Now L_1 is twice the area of the projection of OQR on the plane of yz, and is positive or negative according as rotation from OQ to OR viewed from X, *and therefore also from* P, is, or is not, in the same sense as *rotation from* OY *to* OZ *viewed from* X. Hence we have the same condition for the sign of Δ.

2. Let P and X be on opposite sides of OQR.

The signs of Δ and L_1 are opposite, but the aspect of rotation OQ to OR from X is also the negative of that from P. Hence the conclusion is the same.

It is easy to deduce from this the following rule for the sign of Δ, or of the tetrahedron OPQR, viz., It is positive if the aspect of the circuit P to Q to R from O is the same as that of X to Y to Z; negative if not.

Or, again, in the special case in which OP, OQ, OR are at right angles, $\Delta = +1$ is the condition that it should be possible to rotate the trirectangle OXYZ so that it may coincide with OPQR.

With this condition we have also

$$\frac{L_1}{l_1} = \frac{M_1}{m_1} = \frac{N_1}{n_1} = \frac{\Delta}{l_1^2 + m_1^2 + n_1^2} = +1.$$

Thus L_1, M_1, N_1 *are the direction cosines of the normal to* OQR *on that side from which the aspect of a rotation* OQR *is the same as that of* OYZ *seen from* X. In the ordinary system this latter is clock-wise, so that L_1, M_1, N_1 determine the normal from which the rotation OQ to OR appears clock-wise.[1]

As an illustration let us take Rodrigues's problem to find the co-ordinates (x', y', z') of a point $P(x, y, z)$ after, say, a right-handed rotation ϕ about an axis (l, m, n).

If PN be perpendicular to the axis, P′K to NP, we have

$$ON = lx + my + nz \quad \ldots \quad (1)$$

$$NP = \sqrt{(mz - ny)^2 + \&c.}$$

and the direction cosines of NP are

$$\frac{x - l\,ON}{NP}, \frac{y - m\,ON}{NP}, \frac{z - n\,ON}{NP}.$$

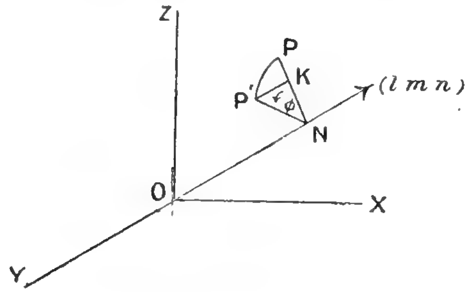
The equation to the plane ONP is

$$\begin{vmatrix} X & Y & Z \\ l & m & n \\ x & y & z \end{vmatrix} = 0$$

[1] One interesting reservation should be made, viz., that the rotation from OQ to OR must be taken the shortest way—*i.e.*, that the rule requires the exclusion of reflex angles.

From the point P′ ONP appears counter-clock-wise, while from X OYZ is clockwise; *therefore the direction cosines of* KP′ are

$$-\frac{mz-ny}{NP}, -\frac{nx-lz}{NP}, -\frac{lx-my}{NP}.$$



Projecting ONQP′ on OX we have at once

$$x' = ON \,.\, l + NP' \cos\phi \,.\, \frac{x - l\,ON}{NP} + NP' \sin\phi\left(-\frac{mz-ny}{NP}\right)$$
$$= x\cos\phi + l ON(1-\cos\phi) - (mz-ny)\sin\phi,$$

and similarly for y' and z'.

If the rotation be left handed we have only to change the sign of ϕ.

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10. *Graphic Methods in Spherical Trigonometry.* *By* Professor G. H. Bryan, *F.R.S.*

FRIDAY, SEPTEMBER 1.

The following Papers and Report were read:—

1. *A Restatement of the Second Law of Thermodynamics and its Bearing upon our Views of Heat and Radiation.* *By* M. Blieden, *M.D.*

After discussing the conceptions involved in the definition of the absolute scale of temperatures, the author proposed a definition of heat which, 'like the definition of absolute temperature, does not depend upon the peculiarities of particular substances or upon hypothetical views as regards the nature of heat and temperature.'

The definition of heat proposed by the author is as follows: Heat is that form of energy which can only be made to produce work through a fall of temperature.

The author showed how by means of this definition of heat much of the vagueness and difficulty at present attending the exposition of the principles of thermodynamics can be got rid of. The proposed definition enables us to keep definite count of the amount of work which is converted into heat owing to the irreversible nature of a process. If, in dealing with the heat received by a body, we take into account not only the heat which is derived through conduction or radiation from a pre-existing store of heat, but also the heat which is generated through friction or analogous causes, then the increase of entropy undergone by a body during any process is always equal to the quotient of the heat received by its temperature during the reception of the heat, no matter whether the process be reversible or irreversible. The great difficulty which the student of thermodynamics at present experiences because of the statement that in an irreversible process increase of

entropy is greater than heat received divided by temperature of reception is thus removed.

Applying his definition of heat as a test to the internal energy of a body, the author showed that it consists of two distinct portions—one which falls within his proposed definition of heat, and one which does not. The first portion is called the thermal energy of the body, the second portion its non-thermal energy. The thermal energy of a body is equal to the product of its entropy into its absolute temperature. This thermal energy can be increased in two ways. In the first place, by raising the temperature of the body without increasing its entropy. The increase of thermal energy in such a case takes place at the expense of non-thermal energy, and is quantitatively equal to the increase of the temperature of the body multiplied by its entropy during the increase. The thermal energy of a body can, secondly, be increased by a fresh supply of heat without raising its temperature. In such a case the increase of entropy of the body multiplied by its temperature during the increase is equal to the fresh supply of heat. Both modes of the increase of the thermal energy of a body can take place simultaneously. To use mathematical symbols, let t be the absolute temperature, ϕ the entropy, and H the thermal energy of a body.

Then $\mathrm{H} = \phi t$, and $d\mathrm{H} = \phi dt + t d\phi$, ϕdt represents the increase of the thermal energy of the body by the first mode, $t d\phi$ represents the increase of its thermal energy by the second mode.

Let E represent the total internal energy of the body, then its non-thermal energy is equal to $\mathrm{E} - \mathrm{H} = \mathrm{E} - \phi t$.

This division of the internal energy of a body into a portion which is thermal and a portion which is non-thermal is free from the defects which attach to Helmholtz's mode of dividing it into a portion which is 'free' and a portion which is latent or 'bound.'

The heat contained in a body does not alter its thermodynamic properties when radiated into space. What is generally called radiating energy falls within the definition of heat proposed by the author, and *is* heat. Thermodynamically, the only difference between radiant heat (including light) and body heat—*i.e.*, the thermal portion of the internal energy of a body—is that the latter is associated with ordinary matter, whilst the former is associated with the free ether of space. All thermodynamic properties of heat are contained in the statement that heat is the product of entropy and temperature, and this statement applies to radiant heat as well as to body heat.

The author next proposed to give a physical interpretation, readily grasped by the understanding, of the thermodynamic meanings of temperature and entropy. Two assumptions are involved in this interpretation. The first assumption is that body heat and radiant heat possess the same thermodynamic properties, because they possess essentially identical physical properties. According to this assumption, which is legitimate on logical grounds and is supported by a number of physical facts, the heat of a body, or its thermal energy, is that portion of its internal energy which possesses physical properties essentially identical with those possessed by radiant heat, whilst the non-thermal energy of a body possesses physical properties different from those possessed by radiant heat. Since radiant heat (including light) is known to be vibratory in nature, the thermal energy of a body must likewise be vibratory in nature. If radiant heat is a periodic electro-magnetic disturbance, then the thermal energy of a body must also be some form of periodic electro-magnetic disturbance. One of the simplest mechanical models of vibrator disturbance is presented by a stretched elastic string which has been put into vibratory motion. The vibratory energy of such a string is equal to the product of two quantities, n and e, of which n represents the number of independently vibrating parts of the string, and e the energy associated with each independently vibrating part. The properties possessed by n and e can be shown to correspond to the properties possessed by entropy and absolute temperature respectively. The author proposes the view—which forms the second assumption—that the vibratory energy called heat consists of a number of separate vibratory disturbances, and that entropy represents the number of separate disturbances, whilst absolute

temperature represents the energy associated with an individual disturbance. Such a view of the nature of heat would enable us to express the principles and conceptions of thermodynamics in very simple mechanical terms. The writer supported the view that radiant heat can be analysed into elementary proportions by considerations based upon the known physical properties of radiation, and also showed how a similar resolution of the thermal energy of a body into elementary proportions is the logical outcome of the electron theory of matter.

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2. *On the Kinetic and Statistical Equilibrium of Ether in Ponderable Matter at any Temperature.*[1] *By* Lord KELVIN, *G.C.V.O., F.R.S.*

1. Consider first the simplest possible case: a piece of solid matter of a few millimètres or a few centimètres greatest diameter, placed in space at the earth's distance from the sun—say 150 million kilomètres; for particular example, suppose two globes of metal, or rock, or glass, or the bulbs of two thermometers, of one centimètre diameter, one of them coated with black cloth and the other with white cloth, side by side, at a distance of a few centimètres or mètres asunder. For the most extreme simplification suppose no other matter in the universe than ether, the sun, and our test globes. From our knowledge of the properties of matter it is obvious that each of the test globes will, in a few minutes of time, come to a steady temperature. In these circumstances, each globe sends out by radiation as much energy of waves in ether as it takes in from the sun, after it has been long enough exposed to come to a steady temperature.

2. The internal mechanism in each globe consists of atoms of ponderable matter, with ether permeating through the whole volume of the globe, and locally condensed and rarefied in the space around the centre of each atom; as the author has assumed, with explanations, in §§ 162, 163, 164, of pp. 412, 413, and in § 3 of pp. 487, 488, of his volume of 'Baltimore Lectures.'

3. The action of this mechanism in the case under consideration involves the communication of energy from the incident waves of sunlight to the atoms of the solid in the surface of the hemisphere illuminated by the sun, and the communication of energy from the atoms to ether in the form of waves travelling out *in all* directions from the surface of the globe. The travelling of this energy through the volume of the globe is carried on according to the laws of the conduction of heat through solids (modified, scarcely perceptibly, by convection currents in the case in which the globe is the bulb of a mercury thermometer).

4. Our present knowledge of the radiational properties of matter does not quite suffice to let us pronounce for certain which of the two globes will have the higher steady temperature, as this depends not only on the well-known higher receptivity of the black surface than of the white for sun-heat, but also on the difference of radiational emissivities of the two surfaces on their hemispheres not exposed to the sun. It seems most probable that the black globe will be steadily warmer than the white; but it cannot be said with certainty that this is true. Suppose for a moment that the steady temperature of the two is the same; and then whiten the hemisphere of the black globe *facing from the sun.* This will cause the black-and-white globe to be warmer than it was, because it will radiate less into void ether than it did when it was all black.

5. Then blacken the hemisphere facing *from the sun* of the globe which was originally all white. Its steady temperature obviously will be lowered. There are now, side by side, two globes, each with a white hemisphere and a black hemisphere, facing respectively towards and from the sun. The globe of which the black hemisphere is towards the sun will certainly be warmer than the other, when a few minutes of time have been given for the temperature of each to become steady.

6. It is not possible for a human experimenter to attain to the extreme simplicity ideally prescribed in §§ 1–5 above. But it has occurred to the author (and probably

[1] See *Philosophical Magazine*, vol. x., p. 285 (1905).

to many others) that instructive experiments might be made by observing the temperatures of two equal and similar thermometers, placed beside each other on a wooden table (or on two similar tables of the same material), or on a cushion or layer of very fine cotton-wool; each thermometer between the folds of a doubled sheet: one of white cloth and the other of black; both exposed in the open air under sunlight, or under the light of a more or less cloudy sky, or under moonlight or starlight, or in the darkest attainable cellar.

7. Not being able at the time to undertake any experimental work, the author asked Dr. Glazebrook if he could conveniently allow some such experiments to be made under the auspices of the National Physical Laboratory. He kindly consented, and asked Dr. Chree to commence an investigation of the kind. On July 28 the author received from Dr. Chree the appended description of his work and statement of results.

8. It is very interesting to see in Dr. Chree's results how large are the differences in the temperatures of the thermometers under black and under white cloth, ranging from 0·5° to 0·6° C., even at times when the sky is covered with dark clouds; and how comparatively moderate are the differences, ranging from 1·1° to 3·6° C., at times of exposure to direct sunshine.

9. Returning to § 4, with one of the globes black over its whole surface and the other white: Suppose the two to be taken to 1,000 times the earth's distance from the sun, and suppose, all at about the same distance (for simplicity of calculation), 999 stars, each equal to our own sun, to be scattered through space round the place of our ideal experiment. The total of radiational energy coming from all these suns to the place of observation will be about one-thousandth of the amount, per unit of time, coming from our own sun in the case of §§ 1, 2, 3; and the difference of steady temperature between the white globe and the black globe may be about one-thousandth of that which it would be in §§ 1, 2, 3. This last supposition would be somewhat similar to an exposure to starlight on a cloudless night, at the top of a high mountain of our earth, with a large number of large screens between the tested globes and the mountain top. It does not, however, seem probable that any differences of temperature will be perceptible on the two thermometers exposed only to stellar radiation from the sky. Even less of difference may be expected when the two thermometers are the darkest attainable cellar. The bolometric method would, of course, be much more sensitive than the comparison of two ordinary thermometers, even of the most extreme sensibility, and it will, the author thinks, be worth while to try, in cases in which the thermometric method fails, or almost fails, to show any difference between the two temperatures.

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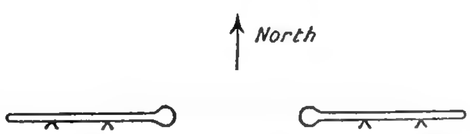
3. *On Temperatures of Thermometers under Black Cloth and under White Cloth. By* Dr. CHARLES CHREE, *F.R.S.*

Experiments with two ordinary thermometers, Nos. 1184 and 1207. Thermometers placed horizontally on small stands fastened to the outside window-sill of the wooden room on the Observatory roof, some 40 feet above the general level of the ground. The arrangement was as shown diagramatically.



The north side of this upper room is entirely in the shade until well on in the afternoon. The cloths were wrapped several times round the bulbs and a small adjacent part of the stems. The thermometers were interchanged and the cloths were interchanged to eliminate difference between positions and between thermometers. Readings were taken at intervals throughout two days.

In every single case the (corrected) reading was higher for the thermometer under the black cloth.

The conditions at the time were noted either as (*a*) bright sunshine; (*b*) sun shining through cloud; (*c*) cloudy; (*d*) black cloud, *i.e.*, dark generally.

An analysis appears in the following tables. The readings are all Centigrade, corrected for scale errors.

Woollen Cloths.

July 12. Time	Position on Right. Black Cloth		Position on Left. White Cloth		Excess of Reading under Black Cloth, Conditions being			
	No. 1184	No. 1207	No. 1184	No. 1207	(*a*)	(*b*)	(*c*)	(*d*)
H. M.	°	°	°	°	°	°	°	°
11 0	23·9	—	—	22·7	1·2	—	—	—
11 20	—	25·8	23·4	—	—	—	2·4	—
11 40	26·2	—	—	23·8	2·4	—	—	—
12 0	—	26·8	24·6	—	2·2	—	—	—
12 20	25·5	—	—	24·5	—	—	1·0	—
12 40	—	25·0	24·1	—	—	—	0·9	—
2 0	25·6	—	—	24·8	—	—	0·8	—
2 10	—	26·3	25·3	—	—	1·0	—	—
2 20	26·5	—	—	25·8	—	—	0·7	—
2 30	—	25·8	24·9	—	—	—	0·9	—
2 40	26·4	—	—	25·2	—	1·2	—	—
2 50	—	27·4	25·6	—	1·8	—	—	—

(*a*) Sunshine. (*b*) Sun visible through clouds. (*c*) Cloudy. (*d*) Dark clouds.

Woollen Cloths changed over

July 12. Time	Position on Right. White Cloth		Position on Left. Black Cloth		Excess of Reading under Black Cloth, Conditions being			
	No. 1184	No. 1207	No. 1184	No. 1207	(*a*)	(*b*)	(*c*)	(*d*)
H. M.	°	°	°	°	°	°	°	°
3 0	25·1	—	—	26·2	1·1	—	—	—
3 10	—	24·8	26·1	—	—	1·3	—	—
3 20	25·1	—	—	26·3	1·2	—	—	—
3 30	—	25·3	26·2	—	—	—	0·9	—
3 40	25·6	—	—	26·1	—	—	—	0·5
3 50	—	24·5	26·1	—	1·6	—	—	—
4 0	25·0	—	—	26·2	1·2	—	—	—
4 10	—	24·5	25·5	—	—	—	1·0	—

(*a*) Sunshine. (*b*) Sun visible through clouds. (*c*) Cloudy. (*d*) Dark clouds.

Cotton Cloths.

July 13. Time	Position on Right. White Cloth		Position on Left. Black Cloth		Excess of Reading under Black Cloth, Conditions being			
	No. 1184	No. 1207	No. 1184	No. 1207	(*a*)	(*b*)	(*c*)	(*d*)
H. M.	°	°	°	°	°	°	°	°
11 0	—	24·6	25·3	—	—	0·7	—	—
11 15	23·5	—	—	24·8	1·3	—	—	—
11 30	—	23·0	23·7	—	0·7	—	—	—
11 45	23·6	—	—	24·8	1·2	—	—	—
11 55	—	23·6	24·5	—	—	—	0·9	—
12 10	23·2	—	—	24·4	1·2	—	—	—
12 20	—	23·3	24·2	—	—	—	0·9	—
12 30	24·3	—	—	24·9	—	—	—	0·6
12 40	—	24·3	25·1	—	—	—	0·8	—

(*a*) Sunshine. (*b*) Sun visible through clouds. (*c*) Cloudy. (*d*) Dark clouds.

Changed Positions of Cotton Cloths.

July 13. Time	Position on Right. Black Cloth		Position on Left. White Cloth		Excess of Reading under Black Cloth, Conditions being			
	No. 1184	No. 1207	No. 1184	No. 1207	(*a*)	(*b*)	(*c*)	(*d*)
H M.	°	°	°	°	°	°	°	°
2 10	27·0	—	—	24·2	2·8	—	—	—
2 20	—	26·0	25·2	—	—	—	0·8	—
2 35	27·3	—	—	25·5	1·8	—	—	—
2 45	—	26·6	25·3	—	1·3	—	—	—
2 55	26·7	—	—	25·6	—	1·1	—	—
3 5	—	25·5	24·9	—	—	—	—	0·6
3 15	26·4	—	—	25·3	1·1	—	—	—
3 25	—	26·9	25·6	—	1·3	—	—	—
3 35	27·0	—	—	25·8	1·2	—	—	—

(*a*) Sunshine. (*b*) Sun visible through clouds. (*c*) Cloudy. (*d*) Dark clouds.

Observations made on a Stand in the Garden about 4 feet above Ground. No Shade.

Woollen Cloths.

July 18. Time	Position on Right. Black Cloth		Position on Left. White Cloth		Excess of Reading under Black Cloth, Conditions being		
	No. 1184	No. 1207	No. 1184	No. 1207	(*a*)	(*b*)	(*c*)
H. M.	°	°	°	°	°	°	°
11 50	28·2	—	—	25·9	2·3	—	—
12 0	—	27·1	25·6	—	—	1·5	—
12 10	25·9	—	—	24·6	—	—	1·3
12 20	—	25·6	24·1	—	—	—	1·5
12 30	24·7	—	—	23·2	—	—	1·5
	White Cloth		Black Cloth				
2 50	24·8	—	—	25·5	—	0·7	—
3 0	—	24·6	25·6	—	1·0	—	—
3 10	24·9	—	—	26·6	1·7	—	—
3 20	—	24·4	25·3	—	—	—	0·9
3 30	24·2	—	—	25·8	1·6	—	—

(*a*) Sunshine. (*b*) Sun visible through clouds. (*c*) Cloudy.

Cotton Cloth.

July 18. Time	Position on Right. Black Cloth		Position on Left. White Cloth		Excess of Reading under Black Cloth, Conditions being		
	No. 1184	No. 1207	No. 1184	No. 1207	(*a*)	(*b*)	(*c*)
H. M.	°	°	°	°	°	°	°
3 40	28·1	—	—	25·8	2·3	—	—
3 50	—	26·9	25·5	—	—	1·4	—
4 0	27·1	—	—	25·4	1·7	—	—
4 10	—	26·0	24·6	—	—	—	1·4
	White Cloth		Black Cloth				
4 20	—	24·4	26·3	—	—	1·9	—
4 30	24·4	—	—	28·0	3·6	—	—
4 40	—	24·3	26·2	—	—	—	1·9
4 50	24·9	—	—	26·2	1·3	—	—

(*a*) Sunshine. (*b*) Sun visible through clouds. (*c*) Cloudy.

4. *Differential Invariants of a Plane and of a Curve on a Plane.* *By* Professor A. R. FORSYTH, *F.R.S.*

5. *Chess Magic Squares.* *By* M. CASHMORE, *M.P.S.*

This paper described chess magic squares—that is, the magic squares having a constant summation along every chess path. The method of construction was given, followed by an investigation showing the number of possible chess magic squares. The paper closed with the theory of their construction.

6. *Computation of* π. *By* M. CASHMORE, *M.P.S.*

This paper gave a better formula than Machin's. The correct value of π was given to ten places by the use of three terms.

7. *Report of the Committee on Electrical Standards.*—See Reports, p. 95.

Section B.—CHEMISTRY.

President of the Section.—George T. Beilby.

The President delivered the following Address at Johannesburg, on Tuesday, August 29:—

In scanning the list of the elements with which we are thoughtfully supplied every year by the International Committee on Atomic Weights, the direction in which our thoughts are led will depend on the particular aspect of chemical study which happens to interest us at the time. Putting from our minds on the present occasion the attractive speculations on atomic constitution and disintegration with which we have all become at least superficially familiar during the past few years, let us try to scan this list from the point of view of the 'plain man' rather than from that of the expert chemist. Even a rudimentary knowledge will be sufficient to enable our 'plain man' to divide the elements broadly into two groups—the actually useful and the doubtfully useful or useless. Without going into detail we may take it that about two-thirds would be admitted into the first group, and one-third into the second. It must, I think, be regarded as a very remarkable fact that of the eighty elements which have had the intrinsic stability to enable them to survive the prodigious forces which must have been concerned in the evolution of the physical universe, so large a proportion are endowed with characteristic properties which could ill have been spared either from the laboratories of Nature or from those of the Arts and Sciences. Even if one-third of the elements are to be regarded as waste products or failures, there is here no counterpart to the reckless prodigality of Nature in the processes of organic evolution.

If we exclude those elements which participate directly and indirectly in the structure and functions of the organic world, there are two elements which stand out conspicuously because of the supreme influence they have exercised over the trend of human effort and ambition. I refer, of course, to the metals gold and iron.

From the early beginnings of civilisation gold has been highly prized and eagerly sought after. Human life has been freely sacrificed in its acquirement from natural sources, as well as in its forcible seizure from those who already possessed it. The 'Age of Gold' was not necessarily 'The Golden Age,' for the noble metal in its unique and barbaric splendour has symbolised much that has been unworthy in national and individual aims and ideals.

We have accustomed ourselves to think of the present as the Age of Iron, as indeed it is, for we see in the dull, grey metal the plastic medium out of which the engineer has modelled the machines and structures which play so large a part in the active life of to-day. Had iron not been at once plentiful and cheap, had it not brought into the hands of the engineer and artificer its marvellous qualities of hardness and softness, of rigidity and toughness, and to the electrician its mysterious and unique magnetic qualities, it is not difficult to conceive that man's

control over the forces of Nature might have been delayed for centuries, or perhaps for ages. For iron has been man's chief material instrument in the conquest of Nature; without it the energy alike of the waterfall and of the coalfield would have remained uncontrolled and unused. In this conquest of the resources of Nature for the service of man are we not entitled to say that the intellectual and social gains have equalled, if they have not exceeded, in value the purely material gains; and may we not then regard iron as the symbol of a beneficent conquest of Nature?

With the advent of the Industrial Age gold was destined to take a new place in the world's history as the great medium of exchange, the great promoter of industry and commerce. While individual gain still remained the propelling power towards its discovery and acquisition, every fresh discovery led directly or indirectly to the freer interchange of the products of industry, and thus reacted favourably on the industrial and social conditions of the time.

So long as the chief supplies of gold were obtained from alluvial deposits by the simple process of washing, the winning of gold almost necessarily continued to be pursued by individuals, or by small groups of workers, who were mainly attracted by the highly speculative nature of the occupation. These workers endured the greatest hardships and ran the most serious personal risks, drawn on from day to day by the hope that some special stroke of good fortune would be theirs. This condition prevailed also in fields in which the reef gold occurred near the surface, where it was easily accessible without costly mining appliances, and where the precious metal was loosely associated with a weathered matrix. These free-milling ores could be readily handled by crushing and amalgamation with mercury, so that here also no elaborate organisation and no great expenditure of capital were necessary. A third stage was reached when the more easily worked deposits above the water-line had been worked out. Not only were more costly appliances and more elaborately organised efforts required to bring the ore to the surface, but the ore when obtained contained less of its gold in the easily recovered, and more in the refractory or combined form. The problem of recovery had now to be attacked by improved mechanical and chemical methods. The sulphides or tellurides with which the gold was associated or combined had to be reduced to a state of minute subdivision by more perfect stamping or grinding, and elaborate precautions were necessary to ensure metallic contact between the particles of gold and the solvent mercury. In many cases the amalgamation process failed to extract more than a very moderate proportion of the gold, and the quartz sand or 'tailings' which still contained the remainder found its way into creeks and rivers or remained in heaps on the ground around the batteries. In neighbourhoods where fuel was available a preliminary roasting of the ore was resorted to, to oxidise or volatilise the baser metals and set free the gold; or the sulphides, tellurides, &c., were concentrated by washing, and the concentrates were taken to smelting or chlorinating works in some favourable situation where the more elaborate metallurgical methods could be economically applied. Many efforts were also made to apply the solvent action of chlorine directly to the unconcentrated unroasted ores; but unfortunately chlorine is an excellent solvent for other substances besides gold, and in practice it was found that its solvent energy was mainly exercised on the base metals and metalloids, and on the materials of which the apparatus itself was constructed.

This to the best of my knowledge is a correct, if rather sketchy, description of the state of matters in 1889 when the use of a dilute solution of cyanide of potassium was first seriously proposed for the extraction of gold from its ores. Those of us who can recall the time will remember that the proposal was far from favourably regarded from a chemical point of view. The cost of the reagent, its extremely poisonous nature, the instability of its solutions, its slow action—such were the difficulties that naturally presented themselves to our minds. And, even granting that these difficulties might be overcome, there still remained the serious problem of how to recover the gold in metallic form from the extremely dilute solutions of the cyanide of gold and potassium. How each and all of these difficulties have been swept aside, how within little more

than a decade this method of gold extraction has spread over the gold-producing countries of the world, now absorbing and now replacing the older processes, but ever carrying all before it—all this is already a twice-told tale which I should feel hardly justified in alluding to were it not for the fact that we are to-day meeting on the Rand where the infant process made its début nearly fourteen years ago. The Rand to-day is the richest of the world's goldfields, not only in its present capacity, but in its potentialities for the future; twenty years ago its wonderful possibilities were quite unsuspected even by experts.

It is not for me to describe in detail how the change has been accomplished; this task will, we know, be far better accomplished by representative chemists who are now actively engaged in the work. But for the chemists of the British Association it is a fact of great significance that they are here in the presence of the most truly industrial development of gold production which the world has yet seen; a development moreover that is founded on a purely chemical process which for its continuance requires not only skilled chemists to superintend its operation, but equally skilled chemists to supply the reagent on which the industry depends.

In 1889 the world's consumption of cyanide of potassium did not exceed fifty tons per annum. This was produced by melting ferrocyanide with carbonate of potassium, the clear fused cyanide so obtained being decanted from the carbide of iron which had separated. The resulting salt was a mixture of cyanide, cyanate, and carbonate which was sometimes called cyanide of potassium for the hardly sufficient reason that it contained 30 per cent. of that salt. When the demand for gold extraction arose, it was at first entirely met by this process, the requisite ferrocyanide being obtained by the old fusion process from the nitrogen of horns, leather, &c. In 1891 the first successful process for the synthetic production of cyanide without the intervention of ferrocyanide was perfected, and the increasing demand from the gold mines was largely met by its use. At present the entire consumption of cyanide is not much short of 10,000 tons a year, of which the Transvaal goldfield consumes about one-third. Large cyanide works exist in Great Britain, Germany, France, and America, so that a steady and sure supply of the reagent has been amply provided. In 1894 the price of cyanide in the Transvaal was 2*s.* per pound; to-day it is one-third of that, or 8*d.* During the prevalence of the high prices of earlier years the manufacture was a highly speculative one, and new processes appeared and disappeared with surprising suddenness, the disappearance being generally marked by the simultaneous vanishing of large sums of money. To-day the manufacture is entirely carried out in large works scientifically organised and supervised, and, both industrially and commercially, the speculative element has been eliminated.

Chemistry has so often been called on to play the part of the humble and unrecognised handmaiden to the industrial arts that we may perhaps be pardoned if in this case we call public attention to our Cinderella as she shines in her rightful position as the genius of industrial initiation and direction.

To this essentially chemical development of metallurgy we owe it that in a community whose age can only be counted by decades we find ourselves surrounded by chemists of high scientific skill and attainments who have already organised for their mutual aid and scientific enlightenment 'The Johannesburg Society of Chemistry, Metallurgy, and Mining,' whose published proceedings amply testify to the atmosphere of intellectual vigour in which the work of this great industry is carried on.

It appears, then, that while gold still maintains its position of influence in the affairs of men, the nature of that influence has undergone an important change. Not only has its widespread use as the chief medium of exchange exercised far-reaching effects on the commence of the world, but the vastly increased demand for this purpose has in its turn altered the methods of production. These methods have become more highly organised and scientific, and gold production is now fairly established as a progressive industry in which scope is found for the best chemical and engineering skill and talent.

The experience of more highly evolved industries in the older countries has

shown that the truly scientific organisation of industry includes in its scope a full and just consideration for the social and intellectual needs of its workers from highest to lowest. It augurs well, therefore, for the future of the gold industry, from the humane and social points of view, that its control should be more and more under the influence of men of scientific spirit and intellectual culture who we may feel assured will not forget the best traditions of their class.

The application of science to industry requires on the part of the pioneers and organisers keen and persistent concentration on certain well-defined aims. Any wavering in these aims or any relaxation of this concentration may lead to failure or to only a qualified success. This necessary but narrow concentration may be a danger to the intellectual development of the worker, who may thereby readily fall into a groove and so may become even less efficient in his own particular work. It certainly requires some mental strength to hold fast to the well-defined practical aim while allowing to the attention occasional intervals of liberty to browse over the wide and pleasant fields of science. But I am certain that the acquirement of this double power is well worth an effort. The mental stimulus, as well as the new experiences garnered during the excursion, will sooner or later react favourably on the practical problems, while the earnest wrestling with these problems may develop powers and intuitions which will lend their own charm to the wider problems of science.

Gold and Science.

If we re-peruse the table of the elements, not now in our capacity as 'plain men' but as chemists, we shall certainly not select gold as of supreme interest chemically. Its position as chief among the noble metals, its patent of nobility, is based on its aloofness from common associations or attachments. Unlike the element nitrogen, it is mainly for itself and little if at all for its compounds, that gold is interesting. In it we can at our leisure study the *metal* rather than the *element*. Its colour and transparence, its softness and its hardness, the density as well as the extreme tenuity of some of its forms—such were the qualities which recommended it to Faraday when he desired to study the action of material particles on light. I should like to repeat to you in his own words the reasons he gave for this choice: 'Because of its comparative opacity among bodies, and yet possession of a real transparency; because of its development of colour both in the reflected and transmitted rays; because of the state of tenuity and division which it permitted with the preservation of its integrity as a metallic body; because of its supposed simplicity of character; and because known phenomena appeared to indicate that a mere variation in the size of its particles gave rise to a variety of resultant colours. Besides the waves of light are so large compared to the dimensions of the particles of gold which in various conditions can be subjected to a ray, that it seemed probable that the particles might come into effective relations to the much smaller vibrations of the other particles.'

I may remind you that Faraday came to the conclusion that the variety in the colours presented by gold under various conditions is due to the size of its particles and their state of aggregation. Ruby glass or ruby solutions he proved are not true solutions, nor are they molecular diffusions of gold, but they contain the metal in aggregates sufficiently large to give a sensible reflection under an incident beam of light. Through the kindness of Sir Henry Roscoe I am able to exhibit to you some of the original ruby gold preparations obtained during this research, which were afterwards presented to him by Faraday at the Royal Institution some years before his death.

By means of refined and ingenious optical methods Zigsimondy and Siedentopf have succeeded in making these ultra-microscopic particles visible in the microscope as diffraction discs; they have, further, counted the number of particles per unit area, and have from the intensity of their reflection calculated their size. In ruby glass the size of the particles in different specimens was found to vary from 4 to 791 millionths of a millimetre. No relation was found to hold between the colour of the particles and their absolute size. This conclusion is in direct contradiction of Faraday's belief already referred to. Mr. J. Maxwell Garnett has

recently shown that the colour of metallic glasses and films is determined, not only by the absolute size of the metal particles, but also by the proportion of the total volume they occupy in the medium in which they are diffused. The results of Mr. Garnett's calculations are in close agreement with a number of the observations on the colour and microstructure of thin metal films which I had already recorded, and they appear to me to supply the explanation of much that had appeared puzzling before. My own observations lead me to think that the actual microscopic particles which are to be seen, and the larger of which can also be measured, in films and solutions or suspensions, do not in any way represent the ultimate units of structure which are required by Mr. Garnett's theory, but that these particles are aggregates of smaller units built up in more or less open formation.

That a relatively opaque substance like gold may be so attenuated that when disseminated in open formation it becomes transparent is contrary to all our associations with the same operation when performed on transparent substances like glass or crystalline salts. The familiar experiment of crushing a transparent crystal into a perfectly opaque powder would not prepare us for the effect of minute subdivision on the transparence of metals. At first it might be supposed that this difference is due to the very rough and incomplete subdivision of the crystal by crushing; but this is not the case, for the perfectly transparent oxide of magnesium may be obtained in a state of attenuation comparable with that of the gold, by allowing the smoke from burning magnesium to deposit on a glass plate. The film of oxide obtained in this way is found to be built up of particles quite as minute as those of which the gold films are composed, yet the opacity of the oxide film is relatively much greater. The minute particles of the dielectric, magnesium oxide, scatter and dissipate the light waves by repeated reflection and refraction, while the similar particles of the metallic conductor, gold, act as electrical resonators which pass on some of the light waves while reflecting others. Specimens of films of gold and silver and of magnesium oxide are exhibited on the table and on the lantern screen. When the metallic particles are in this state of open formation and relative transparence, it was found that the electrical conductivity of the films had completely disappeared. Films of this description were found to have a resistance of over 1,000,000 megohms as compared with only six ohms in the metallic reflecting condition.

Molecules in the Solid State.

My examination of gold films and surfaces has revealed the fact that during polishing the disturbed surface film behaves exactly like a liquid under the influence of surface tension. At temperatures far below the melting-point molecular movement takes place under mechanical disturbance, and the molecules tend to heap up in minute mounds or flattened droplets. These minute mounds are often so shallow that they can only be detected when the surface is illuminated by an intense, obliquely incident beam of light. I have estimated that these minute mounds or spicules can be seen in this way in films which are not more than five to ten micro-millimetres in thickness. A film of this attenuation may contain so few as ten to twenty molecules in its thickness.

When moderately thin films of gold are supported on glass and heated at a temperature of 400°–500°, they become translucent, and the forms assumed under the influence of surface tension can be readily seen by transmitted light. It was in this way that the beautiful but puzzling spicular appearance by obliquely reflected light was first explained as due to the granulation of the surface under the influence of surface tension. Photo-micrographs of these films are exhibited.

Turning now to the mechanical properties of metals, we find that gold has proved itself of great value in the investigation of some of these. It has long been recognised as the most malleable and ductile of the metals, whilst its chemical indifference tends to preserve it in a state of metallic purity throughout any prolonged series of operations.

The artificers in gold must very early have learned that its malleability and

ductility are not qualities which indefinitely survive the operations of hammering and wire-drawing. A piece of soft gold beaten into a thin plate does not remain equally soft throughout the process, but spreads with increasing difficulty under the hammer. If carelessly beaten it may even develop cracks round its edges. We may assume that the artificers in gold very soon discovered that by heating, the hardened metal might be restored to its former condition of softness.

In connection with the study of the micro-metallurgy of iron and steel during recent years it has been recognised that heat annealing is, as a rule, associated with the growth and development of crystalline grains, and Professor Ewing and Mr. Rosenhain have shown that overstrain is often if not invariably associated with the deformation of these crystalline grains by slips occurring along one or more cleavage planes. This hypothesis, though well supported up to a point by microscopic observations on a variety of metals, offers no explanation of the natural arrest of malleability or ductility which occurs when the overstrain has reached a point at which the crystalline grains are still, to all appearance only slightly deformed. At this stage there is no obvious reason why the slipping of the crystalline lamellæ should not continue under the stresses which have initiated it. But far from this being the case, a relatively great increase of stress produces little or no further yielding till the breaking-point is reached and rupture takes place.

The study of the surface effects of polishing, already referred to, had shown that the thin surface film retained no trace of crystalline structure; while it also gave the clearest indications that the metal had passed through a liquid condition before settling into the forms prescribed by surface tension. From this it was argued that the conditions which prevail at the outer surface might equally prevail at all inner surfaces where movement had occurred, so that every slip of one crystalline lamella over another would cause a thin film of the metal to pass through the liquid phase to a new and non-crystalline condition. By observations on the effects of beating pure gold foil, it was found that the metal reached its hardest and least plastic condition only when all outward traces of crystalline structure had disappeared. It was also ascertained that this complete destruction of the crystalline lamellæ and units could only be accomplished in the layers near the surface, for the hardened substance produced by the flowing under the hammer appears to encase and protect the crystalline units after they become broken down to a certain size. By carefully etching the surface in stages by means of chlorine water or cold aqua regia, the successive layers below the surface were disclosed. The surface itself was vitreous; beneath this was a layer of minute granules, and lower still the distorted and broken-up remains of crystalline lamellæ and grains were embedded in a vitreous and granular matrix. The vitreous-looking surface layer represents the final stage in the passage from soft to hard, from crystalline to amorphous. By heating the beaten foil, its softness was restored; and on etching the annealed metal it was found that the crystalline structure also was fully restored. Photomicrographs showing these appearances are exhibited. These microscopic observations were fully confirmed by finding well-marked thermo-electrical and electro-chemical distinctions between the two forms of metal, the hard and soft or the amorphous and the crystalline. The determination of a definite transition temperature at which the amorphous metal passes into the crystalline metal further confirms the phase view of hardening by overstrain and softening by annealing.

It was subsequently proved that *the property of passing from crystalline to amorphous by mechanical flow, and from amorphous to crystalline by heat at a definite transition temperature, is a general one which is possessed by all crystalline solids which do not decompose at or below their transition temperature.* The significance of this fact I venture to think entitles it to more than a passing reference. It appears to me to mean that the transition from amorphous to crystalline is entitled to take its place with the other great changes of state, solid to liquid, liquid to gas, for like these it marks a change in the molecular activity which occurs when a certain temperature is reached. It is entitled to take this place because there is every indication that the change is as general in its nature as the other changes of state. Compare it, for instance, with the allotropic changes with

which chemists have been familiar. These are for the most part changes which are special to particular elements or compounds, and are usually classed with the chemical properties by which the substances may be distinguished from each other. Very different is the amorphous crystalline change, for although in particular cases it may have been observed and associated with allotropic changes, yet the causes of its occurrence are more deeply founded in the relations between the molecules and the heat energy by which their manifold properties are successively unfolded as temperature is raised from the absolute zero. At this transition point we find ourselves face to face with the first stirrings of a specific directive force by which the blind cohesion of the molecules is ordered and directed to the building up of the most perfect geometric forms. It is hardly possible any longer to regard the stability of a crystal as static and inert, and independent of temperature; rather must its structure and symmetry be taken as the outward manifestation of a dynamic equilibrium between the primitive cohesion and the kinetic energy imparted by heat. Even before the discovery of a definite temperature of transition from the amorphous to the crystalline phase we had in our hands the proofs that in certain cases the crystalline state can be a state of dynamic, rather than of static, equilibrium. The transition of sulphur from the rhombic to the prismatic form supplies an example of crystalline stability which persists only between certain narrow limits of temperature. Within these limits the crystal is a 'living crystal' if one may borrow an analogy from the organic world. It can still grow, and it will under proper conditions repair any damage it may receive.

The passage of the same substance through several crystalline phases, each only stable over a limited range of temperature, strongly supports the general conclusion drawn from the existence of a stability temperature between the amorphous and crystalline phases, namely, that the crystalline arrangement of the molecules requires for its active existence the particular kind or rate of vibration corresponding with a certain range of temperature. Below this point the crystal may become to all appearance a mere pseudomorph with no powers of active growth or repair. But these powers are not extinct—they are only in abeyance ready to be called forth under the energising influence of heat. This temporary abeyance of the more active properties of matter is strikingly illustrated by the early observations of Sir James Dewar at the boiling-point of liquid air, and more recently at that of liquid hydrogen. At the latter temperature even chemical affinity becomes latent. In metals it was found that the changes in their physical properties brought about by these low temperatures are not permanent, but only persist so long as the low temperature is maintained. During the past year Mr. R. A. Hadfield has supplemented these earlier results by making a very complete series of observations on the effect of cooling on the mechanical properties of iron and its alloys. The tenacity and hardness of the pure metal and its alloys at the ordinary temperature and at -182° have been compared, and it has been found that these qualities are invariably enhanced at the lower temperature, but that they return exactly to their former value at the ordinary temperature. By the mere abstraction of heat between the temperatures of 18° and -182° the tensile strength of pure metals is raised 50 to 100 per cent. In pure iron the increase is from 23 tons per square inch at 18° C. to 52 tons at -182°; in gold from 15·1 tons to 22·4 tons; and in copper from 19·5 tons to 26·4. This increase is not, I think, due to the closer approximation of the molecules, for the coefficient of expansion of most metals below 0° is extremely small. Neither is it due to permanent changes of molecular arrangement or aggregation, for Mr. Hadfield has obtained a perfectly smooth and regular cooling curve for iron between 18° and -182°, and there appears to be no indication of the existence of any critical point between these temperatures. Further, the complete restoration of the original tenacity on the return to the higher temperature shows that no permanent or irreversible change has occurred during cooling. Everything therefore indicates that the increase of tenacity which occurs degree by degree as heat is removed is due to the reduction of the repulsive force of molecular vibration, so that the primary cohesive force can assert itself more and more completely as the absolute zero is approached.

The metals experimented with by Mr. Hadfield were all in the annealed or crystalline condition, so that the molecules must have exerted their mutual attractions along the directed axes proper to this state. It is to be expected that similar experiments with the metals in the amorphous state may throw light on the question whether and to what extent the crystalline state depends on a dynamic equilibrium between the forces of cohesion and repulsion, or whether a directed cohesion exists fully developed in the molecules at the absolute zero.[1]

The phenomena of the solid state throw an interesting light on the interplay of the two great forces, the primitive or blind cohesion which holds undisputed sway at the absolute zero, and the repulsion due to the molecular vibrations which is developed by heat. This interplay we know continues through the states which succeed each other as the temperature is raised, till a point is reached at which the molecular repulsions so far outweigh the cohesive force that the substance behaves like a perfect gas. The problems of molecular constitution are more likely to be elucidated by a study of the successive states between the absolute zero and the vaporising temperature than at the upper ranges where the gaseous state alone prevails. The simplicity of the laws which govern the physical behaviour of a perfect gas is very attractive, but we must not forget that this simplicity is only possible because repulsion has so nearly overcome cohesion that the latter may be practically ignored. The attractiveness of this simplicity should not blind us to the fact that it is in the middle region, where the opposing forces are more nearly equal, that the most interesting and illuminating phenomena are likely to abound. The application of the gas laws to the phenomena of solution and osmosis appears to be one of those cases in which an attractive appearance of simplicity in the apparent relations may prove very misleading.

Before passing from the specially metallic qualities of gold I will only remind you of the important part it has played in the researches on the diffusion of metals by the late Sir William Roberts-Austen, and in those of Mr. Haycock and Mr. Neville on the freezing-points of solutions of gold in tin, which led to the recognition of the monatomic nature of the molecules of metals.

Molecules in Solution.

It has occurred to me that the practice of the cyanide process of gold extraction presents us with several new and interesting aspects of the problems of solution. As you are aware, the gold is first obtained from the ore in the form of a very dilute solution of cyanide of gold and potassium from which the metal has to be separated, either by passing it through boxes filled with zinc shavings, or by electrolysis in large cells

The solution as it leaves the cyanide-vats may contain gold equal to 100 grains or more per ton, and as it leaves the precipitating-boxes it may contain as little as 1 or 2 grains and as much as 20 grains. In the treatment of slimes much larger volumes of solution have to be dealt with, and in this case solutions containing 18 grains per ton have been regularly passed through the precipitating-boxes, their gold content being reduced to $1\frac{1}{2}$ grain per ton. In round numbers we may say that 1 gram of gold is recovered from 1 cubic metre of solution, while 0·1 gram is left in the solution. Even from the point of view of the physical chemist we are here in presence of solutions of a very remarkable order of dilution. A solution containing 1 gram per cubic metre is in round numbers N/200,000, and the weaker solution containing 0·1 gram is N/2,000,000. It is convenient to remember that the latter contains a little more than $1\frac{1}{2}$ grain per ton. In experiments on the properties of dilute solutions the extreme point of dilution was reached by Kohlrausch, who employed solutions containing

[1] Since the above was written a series of observations has been made on the influence of low temperature on the tenacity of pure metals in the amorphous condition. These observations will form the subject of a separate communication to the Section.

1/100,000 of a gram molecule of solute per litre for his conductivity experiments. These solutions were therefore twice as strong as the gold solution with 1 gram per cubic metre, and twenty times as strong as the more dilute solution. This fact must be my excuse for placing before you the results of a few simple calculations as to the molecular distribution in these solutions, which have certainly given me an entirely new view of what constitutes a really dilute solution from the molecular point of view.

In estimating the number of molecules in a given volume of solution the method adopted is to divide the space into minute cubical cells, each of which can exactly contain a sphere of the diameter of the molecule. In this way a form of piling for the molecules is assumed which, though not the closest possible, may quite probably represent the piling of water molecules. Taking the molecular diameter as $0{\cdot}2 \times 10^{-6}$ millimetres—a figure which is possibly too small for the water molecules and too large for the gold—it is found that a cubic millimetre of solution contains 125×10^{18} molecules, or 125 quadrillions. The head of an ordinary pin, if it were spherical, would have a volume of about 1 cubic millimetre.

If these water molecules could be arranged in a single row, each molecule just touching its two nearest neighbours, the length of the row would be 25,000,000 kilometres. A thread of these fairy beads, which contained the molecules of one very small drop of a volume of 6 cubic millimetres, would reach from the earth to the sun, a distance of about 150,000,000 kilometres.

In a solution containing $1\frac{1}{2}$ grain of gold per ton, or 1 decigram per cubic metre, the ratio of gold molecules to water molecules is as 1 : 193,000,000. Each cubic millimetre of the solution, therefore, contains 6,500,000,000 gold molecules. If these are uniformly distributed throughout the solution each will be about 400 micro-millimetres, or 1/60,000 of an inch, from its nearest neighbours. This is not really very wide spacing, for the point of the finest sewing-needle would cover about 1,500 gold molecules.

If a cubic metre of solution could be spread out in a sheet one molecule in thickness it would cover an area of 1,680 square miles, and nowhere in this area would it be possible to put down the point of the needle without touching some hundreds of gold molecules simultaneously.

According to Professor Liversidge, sea-water contains on the average about one grain of gold per ton. If this is the case, then the above figures for the dilute cyanide solution apply with only a slight modification to sea-water. No drop, however small it may be, can be removed from the ocean which will not contain many millions of gold molecules, and no point of its surface can be touched which is not thickly strewn with these. From this molecular point of view we must realise that our ships literally float on a gilded ocean!

From time to time adventurers arise who attempt to launch upon this gilded ocean unseaworthy ships freighted with the savings of the trusting investor. In order that nothing which has been said here may tempt anyone to contribute to the freighting of these ships, let me hasten to point out that the weakest of the cyanide solutions here referred to is richer in gold than sea-water is reported to be. The practical conclusion from this comparison is sufficiently obvious. If the cyaniding expert, whose business it is to extract gold from dilute solutions, finds that it does not pay to carry this extraction beyond a concentration of 2 or 3 grains per ton, even when the solution is already in his hand, and when, therefore, the costs of treatment are at their minimum, how can it possibly pay to begin the work of extraction on sea-water, a solution of one-half the richness, which would have to be impounded and treated by methods which could not fail to be more costly in labour and materials than the simple process of zinc-box precipitation? It is generally unsafe to prophesy, but in this case I am rash enough to risk the prediction that if ever the gold mines of the Transvaal are shut up it will *not* be owing to the competition of the gold resources of the ocean.

In these calculations with reference to the dilute cyanide solutions it is assumed that the gold molecules are uniformly distributed, that they are practically equidistant from each other. There appears to me to be considerable doubt whether we have any right to make this assumption. Leaving out of account for

the moment the action of the water molecules, it would appear that as long as the gold molecules are so numerous that a uniform distribution would bring them within the range of each other's attraction, we can imagine that all submerged molecules would be in equilibrium so far as the attractions of their own kind are concerned, being subjected to a uniform pull in all directions. This condition would certainly make for uniform distribution. But when the distance between them exceeds the range of the molecular forces, it is evident that an entirely new condition is introduced, and it seems not improbable that the widely distributed molecules would tend to drift into clouds in which they are brought back within the range of these forces. The range of the cohesive forces in water and aqueous liquids is usually taken from 50 to 100 micro-millimetres, and I am disposed to think that ten times this amount would not be an excessive estimate of the range in the case of gold. If the range for gold be taken as 500 micro-millimetres, then the gold molecules of the dilute gold solution, which are spaced at 400 micro-millimetres apart, are just within the range of each other's attraction, and their distribution is, therefore, likely to be uniform. But by a further dilution to half concentration, the equilibrium would be liable to be disturbed, and denser clouds of gold molecules would be formed, with less dense intervals between them.

In preparing the zinc boxes through which the gold solution is passed, very great care has to be exercised to ensure that the contact surface of the zinc is used to the best advantage. With this object the packing of the zinc shavings is so managed that the solution is spread over the zinc surface in as thin sheets as possible. The object, of course, is to bring as many of the gold molecules as possible into actual contact with the zinc. The gold molecules found in the solution leaving the boxes are those which have not been in contact with the zinc. Yet we have seen that these molecules are still so numerous that they are within $\frac{1}{60000}$ of an inch of each other. If these molecules are in a state analogous to the gaseous state, with diffusive energy of the same order as that of the gas molecule, it is difficult to imagine how they can escape without coming in contact with the zinc surface during their tortuous passage through the boxes and being deposited there. Yet they do escape, even when the velocity of the solution in passing over the zinc surfaces is so slow as 10 cm. per minute or 1·6 mm. per second.

We may regard the condition of these isolated gold molecules, or the more complex auricyanide of potassium molecules, as typical of that of the solute molecules in a dilute solution of any non-volatile solid. They are *solid* molecules sparsely distributed among a multitude of intensely active solvent molecules, the temperature of the solution being many hundred degrees below that at which they could of themselves assume the greater freedom of the liquid or gaseous state. These solute molecules have to a great extent been set free from the constraining effect of their cohesive forces, *but it is important to remember that this freedom has not been attained by the increase of their own kinetic energy as in liquefaction by heat.* Their freedom and the extra kinetic energy they have acquired have in some way been imparted to them by the more active solvent molecules; for, if the solvent could be suddenly removed, leaving the solute molecules still similarly distributed in a vacuous space, they would eventually condense into a solid aggregate. This must be the case, for the non-volatile solute has no measurable vapour pressure at the temperature of the solution. The kinetic energy of the solute molecules is of itself quite insufficient to endow them with the properties of the gaseous or even of the liquid molecule, even when their cohesive forces have been weakened or overcome by separation.

If the energy employed in this separation is not intrinsic to the solute molecule then it must in some way have been imparted by the solvent molecules. It therefore becomes important to compare the energy endowment of one set of molecules with that of the other.

Compared with other solids, ice at its freezing-point has very little hardness or tenacity: the cohesion of its molecules has been much relaxed by the great absorption of heat energy between the absolute zero and the freezing-point. If an average specific heat of 0·5 over the whole range be assumed, the heat absorption of one gram amounts to 136·5 calories. In the transition to the liquid state at 0° a

further absorption of 79 calories takes place, so that a gram of liquid water at the freezing-point contains the heat energy of 215·5 calories. The fact that water has the high vapour pressure of 4·6 mm. of mercury at the freezing-point is probably a result of this enormous store of energy. As a liquid, therefore, it is natural to expect that its molecules will exhibit effects proportionate to this great store of energy. This expectation appears to be realised when we consider not only its properties as the universal solvent, but its osmotic and diffusive energy in solutions in which it is the solvent.

To complete the comparison it is only necessary to calculate the heat energy of gold at 0°. Taking its specific heat as 0·032, a gram of gold at 0° contains 8·7 calories. A gram molecule, therefore, contains in round numbers 1,700 calories as compared with 3,880 calories in a gram molecule of water.

Taking into consideration not only this greater store of energy, but also the much smaller cohesive force of water as compared with the majority of solid solutes, there can be no doubt that the active rôle in aqueous solutions of this type must be assigned to the solvent, not to the solute molecules.

This leads to the important conclusion that the energy of solution, of diffusion, and of osmosis is due, not to the imaginary gaseous energy of the solute, but to the actual liquid energy of the solvent molecules. When this conclusion is reached a new physical explanation of these phenomena is in our hands, and we are relieved from the strain to the imagination involved in the application of the gas theory to solutions of non-volatile solids.

This transference of the active rôle to the solvent molecules does not in any way affect the well-established conclusions based on the laws of thermo-dynamics as to the energy relations in these phenomena, for it has always been recognised that these conclusions have reference to the average conditions prevailing in large collections of relatively minute units. Wherever the gas analogy has appeared to hold it has not necessarily involved more than this, that the observed effects are in proportion to the number of these minute units in a given volume.

In applying the gas theory to the physical explanation of osmotic pressure it has been the custom to regard this pressure as directly due to the bombardment of the semi-permeable membrane by the solute molecules. But this conception completely ignores the fact that the pressure developed is a hydrostatic, not a gaseous pressure, and that the hydrostatic pressure results directly from *the penetration of the solvent molecules from the other side of the partition.*

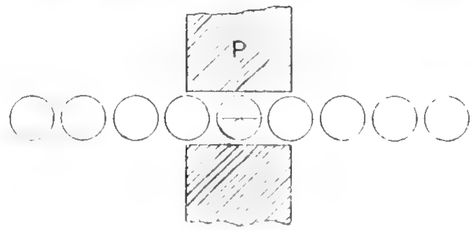
It appears to me more natural to abandon the gas analogy altogether, to regard the molecules as in the solid and liquid condition proper to their temperature, and to apportion to them their respective parts in the active changes according to their obvious endowment of energy.

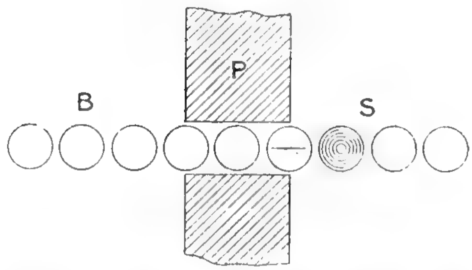
Applying this view to the case of a solution and a solvent separated by a semi-permeable membrane, it is seen that the pressure rises on the solution side, because the pure solvent molecules on the other side have some advantage for the display of their energy over the similar molecules in the solution. *This effect in its most general form may be attributed to the dilution of the solvent by the solute molecules.* In cases where the osmotic pressure appears to obey Boyle's law the effect is exactly measured by the number of solute molecules per unit volume. But the facts of this position are in no way changed if the effect is taken to be due to the activity of an equal number of solvent molecules, for we then see that each solute molecule by cancelling the activity of one solvent molecule on the solution side permits a solvent molecule from the other side to enter the solution.

What the exact mechanism of this cancellation is there is at present no evidence to show, and the caution originally given by Lord Kelvin with reference to the undue forcing of the gas analogy must also be applied to the suggestion now put forward. But as a means of making the suggestion a little more clear I give here a simple diagram on which A represents a single perforation in a semi-permeable membrane, P, on both sides of which there is only pure solvent. For the sake of clearness the molecules are shown only as a single row. Normally there will be no passage of solvent molecules from side to side, for the average kinetic energy of the molecules on both sides is equal. This state of equilibrium

is indicated on the diagram by marking with a cross the molecule which is exactly halfway through the partition.

At B a single solute molecule, S, has been introduced at the right side. If this molecule exactly cancels the energy of one solute molecule at its own end of the row, the equilibrium point will move one molecule to the right, the solvent molecules will move in the same direction, and one of their number will enter on the





solution side. So long as the row includes one, and only one, solute molecule, the equilibrium will remain unchanged and no more solute molecules will pass in. If another solute molecule arrives on the scene, the equilibrium will again be disturbed in the same way as before, and another solvent molecule will pass into the solution.

This mechanism accomplishes to some extent the work of a 'Maxwell Demon,' in so far at least as it takes advantage of the movement of *individual molecules* to raise one part of a system at a uniform temperature to a higher level of energy.

A Mechanical View of Dissociation in Dilute Solutions.

The view that the phenomena of solution depend on the relative kinetic energy of the solvent and solute molecules appears to apply with special force to the phenomena of dissociation in dilute solutions. Under the gas theory there does not appear to be any reason why the solute molecules should dissociate into their ions. So obvious is this absence of any physical motive that Professor Armstrong has happily referred to the dissociation as 'the suicide of the molecules.' Others have proposed to ascribe the phenomenon to what might be called 'the fickleness of the ions,' thus supposing that the ions have an inherent love of changing partners. These may be picturesque ways of labelling certain views of the situation, but the views themselves do not appear to supply any clue to the physical nature of the phenomena. With the acceptance of the view that the phenomena of solution are largely due to the kinetic energy of the solvent molecules, the phenomena of dissociation also appear to take their place as a natural result of this activity. For consider the situation of an isolated molecule of cyanide of gold and potassium closely surrounded by and at the mercy of some millions of water molecules all in a state of intense activity. The rude mechanical jostling to which the complex molecule is subjected will naturally tend to break it up into simpler portions which are mechanically more stable. The mechanical analogy of a ball mill in which the balls are self-driven at an enormous velocity is probably rather crude, but it may at least help us to picture what, on the view now advanced, must be essentially a mechanical operation.

In importing this mechanical view of the breaking down of complex into simpler molecules we are not without some solid basis of facts to go upon. My own observations have shown that even in the solid state the crystalline molecule can be broken down by purely mechanical means into the simpler units of the amorphous state; and, further, that the water molecules of a crystal may by the same agency be broken away from their combination with the salt molecules. Since the publication of the earlier of these observations Professor Spring has shown that the acid sulphates of the alkali metals may be mechanically decomposed into two portions, one of which contains more acid, and the other more base than the original salt. It is important to recognise that in these three apparently short steps the transition has been made from the overcoming of the simple cohesion of similar molecules in contact with each other to the breaking asunder of the chemical union of dissimilar molecules. At each step the solid molecules appear, not as mere ethereal abstractions, but as substantial portions of matter which can be touched and handled mechanically.

The physical properties of a gas are primarily due to its being an assemblage of rapidly moving molecules. These simpler and more general properties can coexist with, and may be modified by, the more complex relations introduced by chemical affinity as it occurs in compound gases and mixtures.

It appears to me quite legitimate similarly to regard the physical properties of a *liquid* as due to its being an assemblage of rapidly moving molecules. The liquid system is highly condensed, and the motions of its molecules are controlled by the cohesive as well as by the repulsive forces. The closer approximation of the molecules may reduce their mean free path to an extremely small amount, or it may even cause their translatory motion to disappear, so that the whole kinetic energy of the liquid molecules may be in the form of rotation or vibration.

As we can imagine a perfect gas, so also may we imagine a perfect liquid, the physical properties of which are as simply related to the laws of dynamics as are those of the gas. But the conditions of the liquid state being also those most favourable to the play of chemical affinity, the internal equilibrium of solutions or of mixed liquids must be a resultant of this affinity together with the primary forces of the ideal liquid state.

An ideally perfect solution—that is, a solution the physical properties of which are determined solely by the number of molecules it contains in a given volume—must consist of a solvent and a solute which have no chemical affinity for each other, so that their molecules will neither associate nor dissociate in solution. Probably only comparatively few solutions will be found which even approximate to this ideal perfection. But it appears to me that the study of the problems of the liquid and the dissolved states may be much simplified by the recognition (1) that the primary physical properties of liquids and solutions are due to the fact that they are assemblages of molecules endowed with the amount and the kind of kinetic energy which is proper to their temperature; and (2) that as these primary physical properties of the liquid and dissolved states may be masked and interfered with by chemical affinity, they should be studied as far as possible in examples where the influence of this force is either absent or at a minimum.

CAPE TOWN.

WEDNESDAY, AUGUST 16.

The following Papers were read:—

1. *Recent Developments in Agricultural Science. By* A. D. HALL, *M.A.*
See Reports, p. 266.

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2. *Recent Researches on the Assimilatory Processes of Plants.*
By HORACE T. BROWN, *LL.D., F.R.S.*

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3. *The Rôle of Enzymes in Plant Economy.* *By* Dr. E. Frankland Armstrong.

In studying the synthesis of disaccharides, both by means of acids and by means of enzymes, attention must be directed to the following points:—

1. That acid and enzyme action are fundamentally similar.
2. That the distinction between them arises from the latter acting selectively, in consequence of their power of associating themselves with the hydrolyte.
3. That the condition of the carbohydrate in solution is of primary importance, but that this condition may to some extent be determined by the enzyme.

THURSDAY, AUGUST 17.

The following Papers and Reports were read:—

1. *The Propagation of Explosions in Gases.* *By* Professor H. B. Dixon, *F.R.S.*

The author gave a history of the researches on the propagation of explosions in gases, and discussed Berthelot's theory and his own 'sound-wave' theory on the mode of propagation. Photographs of the explosion-wave were shown, and the author explained how he had followed photographically the flame from its initiation until the setting up of the 'detonation,' and pointed out the influence of the position of the spark and the length of the column of exploding gases.

Experiments (now being carried out) on the specific heat of gases at high temperatures, showing how the velocity of sound might be determined in a heated gas, were also described.

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2. *The Influence of Phase Changes on the Tenacity of Ductile Metals at the Ordinary Temperature and at the Boiling-point of Liquid Air.* *By* G. T. Beilby *and* H. N. Beilby, *B.Sc.*

The observations recorded in this paper are intended to prepare the way for a more direct attack on the problems of molecular cohesion, by the establishment of clearer views as to the influence of changes of phase on the tenacity of ductile metals at various temperatures.

According to the phase theory of the hard and soft states in metals which was first developed by one of the authors more than a year ago, the changes of state from hard to soft and from soft to hard were shown to be due to the changes of phase brought about, in the one case by heat, and in the other by mechanical deformation or flow. In the ductile metals the crystalline is the mechanically unstable phase, while the amorphous only becomes thermally unstable when a definite temperature is reached.

The comparative mechanical instability of the two phases is well illustrated in the stretching of wires under tension. Annealed wires, which are in the **C** phase, stretch when they are stressed beyond the yield point; hardened wires, which are partly in the **A** phase, do not stretch—they break without extension when their limit of tenacity is reached.

The homogeneous **C** phase in ductile metals has no true breaking-point—it yields and stretches when stressed beyond the elastic limit, and in so doing it passes partly into the **A** phase, and rupture occurs at the breaking-point *of the mixed structure.* The tenacity of the mixed structure approaches, but never quite reaches, that of the homogeneous **A** phase. For the purpose in view it was necessary to obtain the metals as nearly as possible in this homogeneous condition.

Wire drawing was the means employed for the breaking down of the **C** phase. After a wire has been stretched to four or five times its original length by

drawing it through the holes of a wire plate, all the ordinary traces of crystalline structure disappear, but it still consists of minute granules of the **C** phase embedded in a matrix of the **A** phase. Further drawing at the same temperature alters the mixed structure only slightly; for each temperature there appears to be a certain mechanical equilibrium between the phases. By lowering the temperature of drawing the **C** phase is further broken down into still smaller granules, and the mixture approaches more nearly to the homogeneous **A** state.

The observations were made on wires which had been as completely as possible converted into the **A** phase by wire drawing at the ordinary temperature, and in every case the tenacity observed was higher than any which has been recorded by previous observers for equally pure metals.

Gold.	Purity—9,997 per 10,000.			
	Tenacity at 288° absolute	(15° C.)	15·6	tons per square inch.
	„ 53° „	(−180° C.)	22·4	„ „
Silver.	Purity—10,000 per 10,000.			
	Tenacity at 288° absolute	(15° C.)	25·7	tons per square inch.
	„ 53° „	(−180° C.)	34·4	„ „
Copper.	(Conductivity 100%.)			
	Tenacity at 288° absolute	(15° C.)	28·4	tons per square inch.
	„ 53° „	(−180° C.)	36·0	„ „

The wires broken at the ordinary temperature showed no general stretching. There was a slight extension of from $\frac{1}{2}$ to 1 per cent., due entirely to a sharp reduction of diameter at the actual point of rupture. At the boiling-point of liquid air all the wires stretched from 11 to 12 per cent. This stretching was uniform over the whole length between the grips. This was confirmed by exact measurements of the diameter at a number of points.

The appearance of the fractured ends reveals several points of interest. In every case the copper wires showed the cupped formation at the extreme end. This formation is evidently due to the lower tenacity of the central core, due to the presence of gas-bubbles which have been drawn out into long tubes or cells. The silver wires occasionally showed a slight cupped formation, but in this case the gas bubbles to which it was due were globular, as if they had been evolved at the moment of fracture. The gold wires were practically free from sponginess, and the fractures were almost perfectly viscous.

By drawing wires at the lowest possible temperatures it is hoped to obtain the ductile metals in their condition of maximum tenacity, and from the figures then available to be able to calculate the molecular cohesion at the absolute zero.

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3. *On the Atomic Weight of Chlorine.* *By* Professor H. B. Dixon, *F.R.S.*

The author described the experiments made in conjunction with E. C. Edgar on the direct burning of a known weight of hydrogen in a known weight of chlorine—the hydrogen, prepared by electrolysis of barium hydrate, being occluded in palladium, and the chlorine, prepared by the electrolysis of fused silver chloride, being weighed in the liquid state. The resulting atomic weight is higher than that of Stas, but is in close agreement with the recent work of Professor Theodore Richards.

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4. *The Viscosity of Liquid Mixtures at the Temperature of their Boiling-points.* *By* Dr. Alexander Findlay.

The large amount of work which has recently been carried out on the viscosity of mixtures has not to any great extent been found capable of wide generalisation. One reason for this is, no doubt, to be found in the choice of the temperature at which the viscosity of the mixtures was determined. Hitherto all investigations

have been carried out at one temperature, and, as the result of these determinations, it has been found that the viscosity-composition curve for binary mixtures may exhibit a maximum or minimum of viscosity, or may be an almost straight line joining the values for the viscosity of the pure liquids.

In the present investigation the viscosities of the mixtures were determined at the temperature of the boiling-point of the mixture, in which case it was expected viscosity curves would be obtained similar in form to the boiling-point curves, and that maxima and minima in the boiling-point curve would be represented by minima and maxima respectively in the viscosity curve. In the case of benzene and methyl alcohol, the viscosities of which at the respective boiling-points are nearly the same, this expectation appears to be realised. Where the viscosities of the pure liquids at their boiling-points are not the same certain complications, not yet fully worked out, are met with.

In addition to the preceding line of investigation, it is proposed to study also the 'mean molecular weight' of the mixture, with a view to ascertaining the effect of association in the production of irregularities in the viscosity curve.

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5. *Report of the Committee on Wave-length Tables of the Spectra of the Elements and Compounds.*—See Reports, p. 105.

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6. *Report of the Committee on the Study of Hydro-aromatic Substances.*—See Reports, p. 153.

FRIDAY, AUGUST 18.

The following Papers and Report were read:—

1. *A South African Mineral Spring.* *By* Professor P. D. Hahn, *Ph.D., M.A.*

The thermo-chalybeate spring at Caledon is the most remarkable of its kind in the British Empire. The spring yields daily 150,000 gallons of water, and the temperature of the water at the eye of the spring is 120° F. (49° C.). The water was found to have the following composition. One thousand parts of water contain:—

Hydric ferrous carbonate	0·0460
Sodic sulphate	0·0123
Common salt	0·0575
Silica	0·0257
Alumina	0·0108
Calcic sulphate	0·0232
„ carbonate	trace
Magnesic sulphate	0·0150
Potash	trace
Total mineral ingredients	0·1905

In judging a chalybeate water the important point is whether the physiological and therapeutical effect of the use of the water has definitely proved that the iron compounds in the water have been absorbed into the system. The quantity and quality of the accompanying constituents, rather than the absolute quantity of the iron compounds in a water, decide whether it is to be counted among the chalybeate waters. In the Caledon water the accompanying saline constituents which come into account—viz., common salt, sodic sulphate, and magnesic sulphate—form only a very small quantity, which does not in the least prevent

the absorption of the hydric ferrous carbonate into the system. The Caledon spring has proved an effective cure for anæmia, as far as this ailment can be relieved by the use of chalybeate waters.

Denoting by the term *purity ratio* the ratio of the total mineral ingredients to the unit of hydric ferrous carbonate, and comparing the composition of the most famous pure chalybeate waters of the world, it is found that, as regards purity ratio, the Caledon waters hold, with the waters of Spa, the first place; while physically they are unique, no other pure chalybeate water approaching in temperature the Caledon water.

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2. *The Need for Organised Chemical Research in Cape Colony.* *By* C. F. Juritz, *M.A.*

In the past very scanty attention has been paid to purely scientific research in Cape Colony, and in the records of the two colonial institutions whose functions consist in encouraging scientific inquiry there is scarcely a trace of any chemical research undertaken for its own sake. Half a century ago Pappe remarked on the probability that many useful drugs awaited discovery in South Africa, and deplored the absence of scientific research. Yet practically all information possessed on that subject at the present day is due to the farmer, the traveller, and the native.

Several investigations have, however, been made in the Government laboratories under the author's charge, which reveal the need of more thorough research. Of these instances are given.

Considerable tracts of common were found, through deficiency in phosphates, to produce stunted oat crops. This led the author to recommend a chemical survey of the soils of the Colony. An area of 27,000 square miles has been examined, on an average one sample being taken from every sixty square miles. This work, at first interrupted by the war, has now been entirely suspended on account of the financial depression. The investigation had shown that, out of eighteen divisions examined, eight were deficient in lime, two poor in potash, and thirteen were lacking in phosphates.

A curious feature in the soil of many parts of the Colony is the existence of small hillocks, about three or four feet in height and twenty or more yards across. There is a tradition amongst farmers that such hillocks are more fertile than the surrounding soil, and recent chemical analyses have confirmed this view. The origin of these hillocks is unknown, but a popular idea is that they owe their existence primarily to the labours of ants, beetles, and other insects.

The soils of the Colony do not appear to depend for their fertility upon the nature of the underlying geological formation to the extent that may be supposed. Primary soils have been observed to be poorly supplied with the essential elements of fertility, while alluvial soils, originally derived from the same rock, are incomparably more fertile.

Many soils overlying metamorphic slates, sandstones, and intrusive granite are poor in lime, and it has been found that fruit-trees growing on such soils are the more liable to the attacks of insects and fungi, while the wheat crops are the more easily affected by rust.

Examinations of some of the indigenous fodder-plants of the Karroo have been made. Certain of these plants, such as *Mesembryanthemum spinosum* and *Angea capensis*, supply the stock with moisture as well as with solid nutriment in an arid district where droughts are frequent. The *Euphorbia Caput Medusæ* would form a very succulent and nutritious cattle-food if means could be devised for ridding it of a resin which seems to prevent its use.

The natural pests of the country include the prickly pear and locusts, and efforts are being directed towards turning these to good account. The former, if rid of its spines, possesses all the chemical elements of a nutritive cattle-food, and dried locusts are also valuable in this respect. For the latter a demand is being created for poultry feeding.

Determinations of tannin have been made in the barks of several trees and in other vegetable products. The bark of the Cape beech yielded 15·96 per cent. of tannin. In *Acacia saligna* and *Acacia pycnantha* the percentages ranged from 19 to 22 and from 18 to 26 per cent. respectively. The rhizome of *Rumex cordatus* contained 11 per cent., and the 'Ntolwane tuber 14·4 per cent. Experiments showed that it was possible to raise the tannin in *Acacia pycnantha* from 26 to 34 per cent. by judicious slitting.

The advisability of growing sugar beets upon soils containing relatively much potash but little lime is suggested.

It has been found that Cape vines grafted upon American stocks bear far more luxuriantly than when grown upon their own roots, and hence lead to a more rapid exhaustion of the soil—an important fact to remember in connection with the reconstitution of colonial vineyards by means of grafted vines.

The Cape climate has been found to have a marked effect on the milk produced by thoroughbred Friesland cows born in the Colony. Although the Frisian strain be kept pure, acclimatisation appears gradually to produce an all-round increase in the milk solids.

Much attention should be paid to the indigenous plant poisons and drugs. Poisonous principles have been obtained from *Trichilia Dregei*, E. Mayer, and *Mesembryanthemum tortuosum*, L. An alkaloid resembling quinine therapeutically, but differing from it chemically, was extracted from the Umjela, or quinine tree (*Tabernæmontana ventricosa*), which abounds in the Transkei. *Buphane toxicaria*, Herb., and *Acocanthera venenata*, Don, contain poisons which exhibit characteristic chemical reactions, and a poisonous resin was found in *Polygonum tomentosum*. An unknown poison has also been discovered in *Ornithogalum thyrsoides*. Alkaloids and glucosides, as well as oils, resins, and compounds of the aromatic series in abundance, await discovery and employment.

Several analyses of Cape fishes have been made, with a view to glean information as to their nutritive value. From *Thyrsites atun* an oil was extracted of a lower viscosity than sperm oil, but, as regards gumming, similar to rape oil. As far as experiments have gone, this oil seems suitable for light work at low temperatures.

In various parts of the Colony clays have been found, some of which compare well in chemical composition with the best fireclays—Stourbridge, for example; others may be used for similar purposes to the Torbay paints. Besides these, there are kaolins resembling the Cornwall 'china clays.'

Mineral pitch has been observed in samples brought from the Knysna and Barkly East districts. The latter is a limestone possessing all the characters of asphalt rock, and is said to occur in large quantities.

Curious occurrences of free chlorine were reported, due apparently to natural hypochlorites.

The water question on the Government railway system is of great moment, and immense loss, direct and indirect, is annually caused to the administration through the unavoidable employment of bad water.

There is a vast field awaiting research on all these subjects, and others besides, and an urgent necessity exists for finding means to carry on many investigations of the highest importance.

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3. *On an Important Characteristic of Cape Wines.* *By* HEINRICH TIETZ, *Ph.D., M.A.*

The several varieties of vines cultivated at the Cape and known as Green Grape, Stein Grape, red and white Muscadel Grape, Hanepot Grape, and Pontac, appear to have been introduced shortly after the occupation of the Cape by the Dutch.

These varieties were brought from the Rhine and from France at the end of the seventeenth century, and have in the warm climate of the Cape in course of time considerably changed their original character.

At the Cape grapes always become perfectly ripe, and when ripe contain more sugar and less acid than the ripe grapes on the Rhine and in other wine-producing countries of Europe. Notwithstanding this there is a standing reproach against Cape wines in the assertion that they are more acid than European wines. The author has examined some three hundred samples of Cape wines from wine merchants and wine farmers, and found that this allegation cannot be upheld.

4. *Report of the Committee on the Transformation of Aromatic Nitroamines and Allied Substances, and its Relation to Substitution in Benzene Derivatives.*—See Reports, p. 103.

JOHANNESBURG.

TUESDAY, AUGUST 29.

After the President had delivered his Address (see p. 351) the following Papers were read:—

1. *How Oxygen Assists and Retards the Dissolution of Gold in Cyanide Solutions. By* H. Forbes Julian.

A doubt has for some time existed as to the accuracy of the generally accepted idea that free oxygen is primarily essential for the dissolution of gold in cyanide solutions, according to the equation—

$$4KCy + 2Au + O + H_2O = 2KAuCy_2 + 2KOH.$$

Experiments are described which go to show (1) that free oxygen plays no primary part in the reaction, (2) that any assistance given by free oxygen is of a secondary nature, and (3) that free oxygen exerts a retarding influence.

The experiments show that the galvanometer points to the presence of free oxygen as having a retarding influence on the dissolution of the gold, whereas the balance points to it being of material assistance. The cause of the two instruments not agreeing is discussed, and is attributed to the formation of local voltaic circuits. These, in the first instance, deposit hydrogen and oxygen, which, it may be assumed, become occluded at their respective electrodes until the systems are in equilibrium. It is pointed out that cyanogen leaves the solution to combine with the gold rather than that gold particles pass into the solution, and it is shown that cyanogen does not leave the solution until the deposited oxygen has been occluded to a certain degree of concentration. The reason for this is that the expenditure of energy necessary to remove oxygen from the solution is less than that necessary to remove cyanogen; but when oxygen is occluded to a certain concentration, the expenditure of energy then necessary to cause the metal to occlude a further amount becomes as great as that necessary to begin to remove cyanogen from the solution. The available energy is obtained from the metal and solution, and it follows that when the solution is very dilute the available energy is too small to remove cyanogen, oxygen being then alone deposited. From this it may be conjectured that no metal actually combines with cyanogen until the solution has a certain minimum strength.

The presence of dissolved oxygen in the solution has a secondary effect in the process of dissolution, by oxidising the occluded hydrogen produced through the action in the local voltaic circuits. This results in upsetting the equilibrium, and introducing into the circuits concentration gas cells, which soon bring about equilibrium again, but this time with oxygen at both electrodes at different concentrations, instead of hydrogen and oxygen. If, now, excess of dissolved oxygen diffuses to either of the electrodes the equilibrium is again upset, and an E.M.F. is generated by the gas cell in opposition to the E.M.F. generated by the metal couple;

the net result being, of course, a current in the direction of the greater E.M.F. As the strength of the solution increases after a certain point, the E.M.F. due to the metal couple increases rapidly, whereas that due to the oxygen concentration cell remains constant or increases only slowly.

The increase in the E.M.F. of the metal couple appears to be largely due to the formation of AuCy—a compound having a high potential, which acts as an electrode. This deposits in films, varying in density or thickness to a maximum with the strength of the solution. A couple results of Au—AuCy. After this stage of the process, when AuCy is formed, oxygen ceases to exert an influence; That is to say, the metal passes into solution by the AuCy dissolving in the potassium cyanide solution, as one salt dissolves in the solution of another.

The effect of the gas cell is best observed in highly dilute solutions at ordinary or low temperatures. After a certain strength is attained, dependent on temperature, the effect of the gas cell is entirely masked. At the higher temperatures the E.M.F. of the gas cell diminishes, with a corresponding increase in the E.M.F. of the Au—AuCy couple. At boiling-point the retarding oxygen effect of the gas cell on the dissolution of the metal practically disappears.

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2. *The Solubility of Gold in Thiosulphates and Thiocyanates.* *By* H. A. White.

Attention was called to the presence of the above salts in ordinary working cyanide solutions, and to the fact that in presence of certain oxidising agents gold is to some extent soluble in both cases.

The presence of gold in mine reservoirs and in soil under residue dumps is connected most probably with the presence of such salts, since cyanides as such would be speedily attacked and destroyed by the oxidation products of pyrites always present. It was shown that the thiocyanates in presence of such oxidising agents as ferric salts attack gold with considerable ease, and that thiosulphates, which are less stable, exert a less powerful action. Other experiments adduced indicate that in well-exposed dumps cyanide and thiosulphates are not directly concerned with the observed solution of gold, but that thiocyanates alone are of significance in this respect. Results of experiments made on solutions of different strengths with pieces of pure gold show that the rate of attack diminishes rapidly after a few days, and this is traced to ageing of the solution, with consequent loss of available oxygen.

Reference was made to H. S. Stark's process of residue re-treatment, which is resulting in the profitable extraction of a large portion of the gold in certain of the residue dumps on the Rand.

WEDNESDAY, AUGUST 30.

The following Papers were read:—

1. *The Law Governing the Solubility of Zinc Hydrate in Alkalis.* *By* James Moir, *M.A., D.Sc.*

It is a fact well known in analytical chemistry that when salts of zinc are treated with caustic potash or soda the precipitate of $Zn(OH)_2$ dissolves in excess of the alkali. It is rather extraordinary that no quantitative investigation of this phenomenon seems to have been made, and this is the *raison d'être* of this paper.

The phenomenon is essentially an equilibrium between alkali and zincic acid, and this equilibrium may be reached from both sides, *i.e.*, (1) addition of excess of zinc hydrate to caustic alkali, and (2) dilution with water of a strong solution previously saturated with zinc hydrate. In the latter case some of the $Zn(OH)_2$ is re-precipitated, and on standing an equilibrium is reached which, as in the first case, depends solely on the concentration of the free alkali.

Observations have been made on both lines over the range from 7N to ·01N

alkali, below which the amount of zinc dissolved is insignificant, being little greater than that due to the solubility of zinc hydrate in pure water. In addition, the author has succeeded in showing that the experimental results can be deduced from the ordinary assumptions of the ionic theory, and, in particular, that the results given by caustic potash are the same as those given by caustic soda when expressed in gram molecules; so that it follows that the solubility of zinc hydrate in alkali depends solely on the concentration of hydroxidion in the solution.

It was also shown that no definite chemical compounds (such as $ZnO.8KOH$) exist, since the curve obtained by plotting the results is approximately a parabola, and its tangent never passes through the origin.

A practical result of the investigation is to show that in working cyanide solutions scarcely any of the zinc is present as zincate, but nearly all is zinco-cyanide.

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2. *The Functions of the Metallurgical Laboratory.* *By* GERARD W. WILLIAMS.

The subject of the paper was dealt with under four heads:—

(*a*) The laboratory in regard to metallurgical research.
(*b*) The laboratory as a testing department for mine supplies.
(*c*) *Personnel* and educational training of the staff.
(*d*) Equipment.

(*a*) The utility of the laboratory to metallurgical research is based on the relative value of small-scale experiments to the working processes they are designed to illustrate.

In general it may be said that all processes, the fundamental principle of which lies in the inter-reaction of two or more bodies, can be tested with accuracy in the laboratory.

Subject to the laws of mass action, the reaction which takes place in a test tube will take place equally on a working scale. The author on one occasion conducted a lengthy series of tests on the extraction obtainable from banket ores under different conditions as to crushing. The results obtained by bottle tests were completely borne out in actual practice.

Questions involving mass action, slow oxidation, and physico-chemical changes are less easily studied in the laboratory, but considerable accuracy is possible.

Other instances of actual improvements introduced as a result of small-scale experiments were quoted, and stress was laid on the importance to the mining industry of the Witwatersrand of the establishment of a fully equipped laboratory fitted with a ten-stamp battery and all necessary plant.

The full effect of any modification in working conditions would be noted, as it would not be obscured by other issues. Similar experimental plants are to be found in all the important gold-mining centres of the English-speaking world.

(*b*) The importance of the testing of all mine supplies is obvious. This is done in all large European and American works. The twentieth century might well be called the age of adulterants. To such a pitch has this practice been carried that all large firms, home and Transatlantic, now buy all supplies on contract specification only. There is great need in this country for such a department. The author quoted instances of adulteration of supplies which have come before him, and showed how high prices are frequently paid for worthless and even harmful goods; coal, lime, cyanide, and all mine supplies of a similar nature may be tested and bought on true value only. This involves a direct saving more than equivalent to the expenses of the department. The analysis of boiler-feed waters, flue gases, and the conducting of full boiler tests, furnishes information of great value to the engineer.

The advantages of the metallurgical laboratory from this standpoint are obvious, in that the results have an immediate cash value, and were the laboratory to accomplish nothing else, its value to the industry would be assured.

(*c*) This question was considered from the standpoint of the older universities of England. The author contrasted the value of the science schools of Oxford and Cambridge with similar schools in American universities. He deplored the want of true perspective evidenced in the former schools and the too great differentiation of the theoretical from the practical. Only by the breaking down of this artificial barrier can the older universities compete with the broader schools of newer universities.

(*d*) The equipment of the laboratory, metallurgical testing works, and general control of the plant were briefly discussed.

In conclusion, the author expressed his consciousness of the brief manner in which he had outlined the scope and utility of the metallurgical laboratory, but he is confident that the establishment of a central department on the lines laid down, and maintained at the cost of all the mines, would furnish abundant justification for the optimistic views which he holds as to the value of the metallurgical laboratory to the gold-mining industry of the Witwatersrand.

3. *Notes on Economic Problems in Metallurgy on the Witwatersrand.* *By* S. H. Pearce.

This paper consisted of a discussion of the broader principles of metallurgy involved, under various headings:—

1. *Sorting.*—Under this heading a plea was made for a more systematic sampling of the quartzite adjacent to the reef matter mined, in order to avoid discarding 'waste' from the sorting tables which carries payable values in some cases.

2. *Milling.*—This subject included discussion of the fineness to which the ore should be reduced, both by the stamp mill and subsequent regrinding by the tube mill, and concluded that the marked increase of duty with the coarsest mesh used indicates probable development in this direction in the future.

3. *Amalgamation.*—This section pointed out the advantages of amalgamation prior to cyanide treatment, and that the percentage recoverable by this method is largely dependent upon the fineness to which the ore is reduced.

4. *Concentration.*—This section gave the reasons for discarding mechanical concentration, by reason of the high extraction possible from the pyritic portion of the ore by cyanide treatment after regrinding.

5. *Slimes Treatment.*—Various methods of slimes treatment were discussed, and the local advantages of the decantation method were shown, as compared to those processes in use elsewhere.

In conclusion, the advantages of the proposed 'all-sliming' of the ore were compared to the present method of separate sand and slime treatment; and modifications of plant design were given, which appear to show a saving of nearly half of the present cost of installing the reduction plant.

4. *On a Radio-active Substance Discovered in the Transvaal.* *By* R. Lewis Cousens, *M.I.E.E.*

The author described the experiments which he had conducted with an alluvial ore, consisting principally of pit clay with sand, and leaving on concentration a heavy deposit of black iron sand and other minerals, and which tended to prove that the ore contained a radio-active substance. The radio-activity of the ore was tested by means of the electroscope, by photographic methods, and by proof of the ionisation of the air in a bottle containing some of the concentrates. The results, together with the results of chemical treatment of the concentrates, pointed to the presence of radium in the ore, although apparently both uranium and thorium were absent. The author suggested tentatively that the radium may have been produced from titanium, which is present in the form of rutile in the concentrates.

FRIDAY, SEPTEMBER 1.

The following Papers were read:—

1. *The Soils of the Transvaal from their Chemical Aspect.* *By* Herbert Ingle, *F.I.C.*

The results of the analyses of some seventy or eighty samples of soil, collected from various parts of the colony, were given, together with details as to the methods employed in their collection and examination.

A discussion of the results and of the general conclusions to be drawn from the material already obtained was also included.

A comparison was made between European and Transvaal soils, with reference to their composition, and especially to the interconnection of their chemical composition and fertility as indicated by field experience.

It was shown that to take English standards in judging of fertility from chemical analysis may lead to erroneous conclusions in the case of tropical or subtropical soils, and that, given a sufficient supply of water, a soil of apparently poor quality from analytical results may yield luxurious crops under the favouring conditions of growth existent in this colony.

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2. *Pretoria Rain and its Content of Combined Nitrogen.* *By* Herbert Ingle, *F.I.C., F.C.S.*

The rain falling in Pretoria since February 1, 1904, has been collected, and measured, and its content of nitrogen existing as ammonia and as nitrates and nitrites has been determined each week.

The results were given both in parts per million of rainwater and also in weight of nitrogen per unit area — grammes per hectare and pounds per acre. Comparisons with English and other determinations were given.

The results showed that the amount of combined nitrogen brought down in the rain in Pretoria is considerably greater than the average amounts in Europe.

Certain relationships between the richness in nitrogen and the total rainfall each week are observable.

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3. *A Fuel of the Midland Districts of South Africa.* *By* E. H. Croghan.

The region known as the Midland Districts is dry and treeless, with a scarcity of rainfall. The better part of this region is suitable for sheep-farming, being sparsely covered with bushes, the foliage of which constitutes the chief food of sheep and cattle. These bushes are very hardy, and have an enormous root system, penetrating to a great depth. They are of great nutritive value, as they contain a comparatively large quantity of digestible carbohydrates, principally starch.

These carbohydrates are associated in the plant system with potash compounds; therefore we also find a large quantity of potash in sheep excreta.

This manure accumulates in considerable quantity in the kraals (a sort of paddock near the homestead).

The farmer has no use for this manure as such, because he has no water for irrigation, and gets a very insufficient supply from his wells. In some parts of the sheep districts it is a well-known fact that the drought is often so severe that the lambs are killed to save the ewes.

The farmer therefore only uses the dung as fuel. He has it dug out and cut into bricks, somewhat resembling those made of spent tan, which in some Continental countries are similarly used as fuel. The ashes are thrown aside, and frequently accumulate as small mounds near the homestead.

These ash-heaps, as well as the manure itself, are of great economic value, more particularly for heavy, clayey soils.

The Cape farmer obtains a fair supply of guano from the Guano Islands along the coast, and if he were to supplement this with ashes of sheep dung, thus supplying the necessary potash (guano being principally of a nitrogenous and phosphatic nature), he would secure an excellent manure for raising all kinds of grain and root crops, especially potatoes.

For industrial or domestic purposes these ashes may be used for the production of potassium carbonate, which can be employed in making soft soap, since fat, tallow, and beef suet are also by-products on most farms.

As potassium carbonate is, so to speak, the starting-point in the production of all potash compounds, its uses are many, one being the formation of cyanide of potash, employed largely in gold extraction.

Section C.—GEOLOGY.

President of the Section.—Professor H. A. Miers, M.A., D.Sc., F.R.S.

The President delivered the following Address at Johannesburg, on Tuesday, August 29:—

In opening the proceedings of Section C in its first visit to South Africa, and speaking first on behalf of those who are visitors, I think I may justly claim that to no Section of the British Association can this visit be more interesting or even more exciting than to us; we enter for the first time a country whose geological features and history, and whose mineral productions, have long aroused the keenest interest among European geologists and mineralogists.

We have followed the discoveries and discussions of South African writers; we have read your views and have become familiar with your terminology; we have heard the reports of those who have visited the country, either as travellers or with the special object of investigating its geological problems or mineral resources; and, indeed, ever since the Geological Society of London received the historic papers of Andrew Geddes Bain, the father of South African geology, many of the memoirs of your own geologists have been communicated to European societies and journals; we have looked from afar with yearning eyes upon this alluring country; and at length we have found ourselves upon its shores.

It has not been given to many of us to see those great pioneers of South African geology whose work was done in the days before amateurs and experts could come out for a few weeks or months to take a hurried survey of the country; but their enduring labours, which have laid the foundation of all subsequent work, are well known to us, and it is not necessary for me to do more than mention the familiar names of Bain, Wyley, Stow, Atherstone, Sutherland, and Dunn. Of these only the last named survives; but when one remembers that his maps of North Cape Colony and of Orange River Colony have served as the basis of the maps now in use, one is reminded how recent is the whole history of South African geology, and how much was achieved in so short a time by these early workers.

It is exactly one hundred years since John Barrow wrote the concluding words of his 'Travels in South Africa' which first directed attention to the geology of this country; it is only fifty years since Bain sent home the manuscript of the classic papers to which I have already alluded.

Since their days many have been the scientific visitors to the country who have remained there for longer or shorter periods, whose works have made us familiar with its problems and have contributed to their solution; the names of Cohen, Draper, Exton, Gibson, Green, Griesbach, Passarge, Rubidge, Sawyer, Schenck, and Seeley recall some of the most substantial scientific work which has been done either by visitors or residents. Several others who, without visiting the country, have by their researches in Europe helped to unravel the problem of South African

stratigraphy were enumerated by Dr. Corstorphine in his interesting and exhaustive Presidential Address last year.

If we must regret that we never had the opportunity of seeing the great pioneers and the earlier workers, we may rejoice that we have been able to meet those who are now actively engaged in continuing their labours; the period of cursory visits and fragmentary essays is closing and the era of deliberate and systematic surveys is beginning; we now look for authoritative information to the Cape Survey inaugurated by Dr. Corstorphine in 1895 and so ably continued by his successor Mr. Rogers; to the Transvaal Survey begun by Dr. Molengraaff in 1897 and auspiciously revived under Mr. Kynaston; and to the Natal Survey which Mr. Anderson has so successfully directed since 1901. I hope that it will not be long before there is no part of South Africa outside the direct supervision of a systematic and well-ordered survey.

There is perhaps some danger lest in a developing country, where the commercial possibilities are prominently before all eyes, the immense importance of such surveys should be overlooked, and lest it should be thought that what appears to be purely scientific research may be left to take care of itself until the mineral wealth of the country has been explored. I cannot enter too emphatic a protest against such a view; how closely the two interests are knit together must be apparent to anyone who reflects that the nature and sequence of the more northerly formations which have yielded coal, diamonds, gold, and metalliferous deposits can only be studied in the light of the more intelligible geology of Cape Colony and Natal. It is, moreover, immensely to the advantage of South Africa that you have intimately connected with the mining industry geologists of such training as Doctors Corstorphine, Molengraaff, and Hatch, who have all gained valuable experience upon geological surveys.

I may now, perhaps, cease to speak merely as a representative of the visitors and identify myself more closely with the Section as a whole; for the most gratifying feature of this meeting is that it is not merely a visit of strangers who are enjoying your hospitality, but that with Section C of the British Association is fused Section B of the South African Association, so that for the time being we are all colleagues; and even such vexed questions as the correlation of the rocks of the Transvaal or of Rhodesia with those of the Cape, or the origin of Banket, or of Blue Ground, or the extension of the Main Reef Series (perhaps it is no longer necessary to include the problem of the Dwyka conglomerate) can be discussed by us on the spot as members of the same body inspired by the same earnest desire for truth.

I began these preliminary remarks by asking that I might be regarded as the spokesman of the visitors, and therefore represented myself as a geologist visiting the country for the first time. I must, however, make a frank confession. Not only is this my second visit to the country, but I have not even any claim to be called a geologist. My training and experience have been such that upon many of the questions which must be most interesting to this Section I am not competent to form an opinion or to appreciate properly the evidence. I must, therefore, crave your indulgence if in this Address I refrain from discussing any of the problems of surpassing interest which naturally engage the attention of those who are occupied with the study of South African geology. It would indeed be an impertinence for me to do so.

I venture, however, to hope that the frontier between geology and mineralogy is so ill-defined—if indeed a scientific frontier can be said to exist—that the thoughts and occupations of one who has confined himself to the study of minerals, and that rather in the laboratory than in the field, are not alien to the interests of Section C.

Experimental Geology.

A somewhat lamentable aspect of modern science is the vast array of unorganised facts which are awaiting co-ordination; this is too often because they have been amassed without any definite idea of the purpose which they may serve; con-

sequently it may happen that laborious observations belonging to one science may fail to attract the regard of a neighbouring science merely for want of the mutual acquaintance which would make them serviceable to each other; and in these days of exclusive specialisation the introduction which might lead to a happy union is, perhaps, not brought about for years. None can be more fully alive to the importance of such an alliance than those whose work lies on the borderland between different sciences; the mineralogist, for example, is in contact on the one side with the experimental sciences of chemistry and physics, and on the other with geology, which has scarcely yet entered the experimental stage. He cannot fail to be impressed by the need of the appeal to experiment on the geological side of the border, and it is perhaps his duty to supply the want as far as lies in his power.

Owing to this very need some of the most difficult problems in geology are those concerned with the origin of minerals and of the rocks which they compose. One need but recall the many theories which have been held about the origin of mineral deposits, the filling of metalliferous veins, the local concentration of certain minerals, the distribution of various rock types, the existence of rock magmas of diverse compositions, and the differentiation of their constituents. Could the importance and difficulty of such problems be better illustrated than in South Africa, and by its two most valuable minerals, gold and diamond?

Now all these are problems in which direct appeal may, and indeed must, be made to laboratory experiments; the well-defined minerals of which the earth's crust consists do not, after all, number much more than 800, and of these many have already been manufactured in the laboratory. Speculation upon the origin of rocks and minerals should surely be controlled by the results of experiments, and equally should experiment which is to be of service to geology be guided by a knowledge of the problems to which it is to be applied. It will be my object in the present Address to illustrate these principles by examples drawn from recent experimental work which can be applied to geological problems, and to indicate the course which such research is likely to pursue in the immediate future.

It seems to be sometimes expected of a Presidential Address that it should contain a summary of the progress of a science during past years, and this is no doubt very useful and instructive; but if we are to go forward in our scientific work we must not be satisfied with the patient accumulation of details, or content to congratulate ourselves upon the number of them which have been amassed. I venture to think that it is more profitable to take our stand upon the actual work of to-day, and from that tower of observation to look forward to the future rather than backwards to the past; to exclaim with the poet—

> 'No, at noonday in the bustle of man's work-time
> Greet the unseen with a cheer!
> Bid him forward.'

It would be interesting enough to trace the history of the artificial reproduction of minerals, beginning with the famous experiment of James Hall; to follow the lines that led to the development of the French School during the last half of the nineteenth century; to dwell on the researches of Senarmont, Ebelmen, Daubrée, and Sainte-Claire Deville; to show how the increasing study of petrography and the invention of the electric furnace have led to renewed activity in the attempts to reproduce igneous rocks and the rock-forming minerals; to discuss the more modern experiments of Fouqué and Lévy, Lagorio, Loevinson-Lessing, and Morozewicz; or to describe the manufacture of many an interesting mineral by de Schulten and others who are actively prosecuting research of this nature, including such sensational achievements as the production of the ruby by Frémy and of the diamond by Moissan.

Instead, however, of attempting a survey of all that has been done, or even of all that is being done in the artificial reproduction of minerals, let me adhere to the principle that I have laid down, and discuss only a few of those researches,

now being carried on, which promise to be most fruitful because their methods and aims are inspired by the discoveries and views of modern chemistry and modern physics.

Van 't Hoff's Work on the Salt Deposits.

Among such researches the most remarkable are those conducted by Professor van 't Hoff and his pupils during the last eight years upon the Stassfurt salt deposits. These deposits are of enormous extent, more than 1,000 feet thick, and consist of fairly well-defined layers of various sulphates and chlorides of sodium, magnesium, and potassium, and their double salts and hydrates. It has long been supposed that the minerals have been derived from the evaporation of sea-water which contains in solution the chlorides of sodium, magnesium, and potassium, with sulphate of magnesium and small quantities of calcium salts; and the general sequence of the minerals is that of their solubility; the less soluble sodium chloride crystallised out first and is at the bottom, while the very soluble magnesium chlorides, having been the last to crystallise, occupy the top of the series. But the problem is by no means so simple as to be one of mere solubility in water; the rock salt itself persists through the whole series, and some of the associations are difficult to explain.

As is well known, the modern theories of solution mainly rest upon the behaviour of dilute solutions from which the principles of electrolytic dissociation have been deduced; but in the case of the concentrated solutions from which dissolved substances actually crystallise, very little is really known about the liquid itself. A great deal is known, however, about its equilibrium with the solids that separate from it, and the general laws of this equilibrium are expressed by the phase-rule deduced from mathematical considerations by Willard Gibbs, which states how many mechanically separable constituents can coexist under varying conditions of equilibrium in a system containing a definite number of chemical components.

A solution saturated with a given substance is one which is in equilibrium with that substance when the latter is in contact with it in the solid form; the phase-rule indicates the number of solids which must be in contact with a given solution; the only difficulty in practice is to determine the nature of the double salts or distinct hydrates that may be formed.

By means of a series of experiments upon the solubilities of these salts, either singly or in the presence of one another, in order to determine the composition of solutions saturated simultaneously with two or more substances, it is possible to obtain a graphic representation of all possible solutions containing the salts present in sea-water. From this the course of crystallisation of any particular solution, for example sea-water, can be predicted.

The general sequence thus theoretically predicted is as follows: (1) Rock salt; (2) Rock salt with the magnesium sulphate, epsomite; (3) Rock salt with the double sulphate of potassium and magnesium, leonite; (4) Rock salt with leonite and the potassium chloride, kainite; (5) Rock salt, the magnesium sulphate kieserite, and the double chloride of potassium and magnesium, carnallite; (6) Rock salt, kieserite, carnallite, and the magnesium chloride, bischoffite. This last combination will persist until all the water is evaporated. This is found to be the general sequence, not only of the salts obtained on evaporating sea-water at 25°, but also of the Stassfurt deposits.

Up to this point the results have been summarised by Dr. E. F. Armstrong in a report presented to the British Association in 1901. Since that date the research has been prosecuted actively by van 't Hoff and his pupils, and now the conditions of equilibrium at 25° have been mapped out, not only for the above compounds, but also for the minerals thenardite, glaserite, astrakanite, and reichardtite, which occur in these deposits. The whole process of crystallisation of the solution, from which no fewer than twelve different salts have separated, can therefore be predicted, and their sequence and associations can be traced through numerous stages, beginning with the separation of rock salt and ending with a mixture of rock salt, kieserite, carnallite, and bischoffite.

In reconstructing the history of these deposits account must also be taken of the varying vapour pressures of the solutions which are saturated with the different compounds, as this really determines which particular compounds are stable, so that the matter is by no means so simple as might appear from this brief sketch. It is further necessary, in order to bring the process within reach of calculation, to assume that each deposit is removed from contact with the mother liquor after it has crystallised out; but fortunately this is practically what has happened in the Stassfurt deposits, for each layer is more or less separated from the succeeding one by an intervening layer of clayey material.

It may be possible even to go a stage further and obtain a clue to the actual temperatures that prevailed, for two minerals, langbeinite and löweite, are absent from the theoretical model made by van 't Hoff to represent what must happen during evaporation at 25°; and this indicates that while the deposits crystallised the temperature really rose higher than 25°, probably as high as 43°; in fact, after the conditions of equilibrium have been worked out, the appearance or disappearance of certain minerals can be used as a sort of geological thermometer, capable of indicating the limits within which the temperature can have varied.

The whole investigation is a splendid example of experimental research devoted to a particular problem and directed by a well-established theory; the chemist in his laboratory has now succeeded in tracing the changes that took place ages ago in the bed of a land-locked sea as it laid down its contents and finally became a dry basin, although he is not able to reproduce the original conditions or to work for the long periods which Nature had at her disposal. Without the logical consideration of the conditions necessary for equilibrium, countless experiments might be made upon these salts, and an immense amount of speculation might have been devoted to their possible reactions in the liquid state, about which we know so little, instead of to their equilibrium when solidifying, about which we know so much more.

Some Petrographical Problems.

The other geological problems which I have mentioned have also been beyond the reach of actual experiment, for it is hopeless to attain the immense pressures and high temperatures or the enormous time that may have been required for the growth of natural minerals in rocks and veins; and so when difficulties are encountered there is a tendency to 'explain' them (if the word may be so misused) by reference to the mysterious effect of conditions which cannot be brought directly within the reach of experiment.

I cannot help thinking that this has to some extent occurred in the discussion of the petrographical problems which I propose to consider next. There are two great liquid reservoirs from which minerals have crystallised—the sea, with its dissolved salts, and the subterranean baths of molten silicates, from which the igneous rocks have been derived. It is true that in the sea two of the constituents, water and sodium chloride, largely predominated over the others; but, after all, both sea and lava are liquids subject to the same physical and chemical laws.

An admirable summary of the evolution of petrographical ideas was given in the Presidential Address to the Geological Society of London in 1901 by Dr. Teall, who dealt both with the consolidation of rocks from molten magmas and their differentiation into species. It is not, therefore, necessary for me to consider anything but recent work which has been done during the last four years, and the earlier controversies may be left out of account.

Among the many problems relating to the mineral and chemical constitution of rocks which have yet to be solved, two, and those perhaps the most important, should lend themselves most readily to experimental treatment. The first is the problem of rock differentiation: why does a magma, even one which has presumably crystallised *in situ*, separate itself into zones, or layers, or streaks of different constitution? And the second is the problem of mineral differentiation: why does a granite magma, for example, crystallise as a mixture of the particular

minerals mica, felspar, and quartz, and why is the least fusible mineral the last to crystallise?

It will scarcely be possible for me to deal in this Address with more than the second of the two problems, but it will be apparent from the somewhat parallel case of the salt deposits that the mere order and manner of crystallisation of a mass of molten silicates must be a sufficiently complex problem to exhaust our attention for the present.

Magmatic Differentiation.

If we are to consider only recent experiments which have a bearing upon the problems of rock magmas, it is not necessary to say much about the first great petrographical problem, that of the differentiation of magmas into various rock types; for in this connection very few experiments have been made, and practically none of recent date. Observations of the facts as they present themselves in the field accumulate every day; almost every important petrographical region is being studied with the particular object of determining the mutual relations of its rock masses and the factors which have contributed to their differentiation. They have been ably discussed by Becke, Brögger, Becker, Cole, Harker, Iddings, Judd, Lacroix, Lévy, Pirsson, Rosenbusch, Teall, Washington, Zirkel, and many others; appeal has been made to the action of gravity, of temperature differences, of diffusion, of electric currents, of fractional crystallisation, of refusion, of chemically combined water, of absorption of the country rock; but with the exception of a single case, observed in the glassworks of Targowek, in which the top of a molten glass was found to contain less lime and more silica than the bottom, and some observations by Doelter upon boron-glass, there is scarcely a single experiment upon silicates which really bears directly on the question. That artificial glasses are far from homogeneous is known to glass-workers and to makers of lenses, but there is nothing comparable with the splitting of a magma into two or three distinct liquids which solidify as different rocks.

It is in the case of laccolites that the problem ought to present itself in the simplest form, for we may regard them as basins of igneous rock which have been practically imprisoned within solid walls and have crystallised *in situ*. There can, I think, be no doubt that differentiation has generally taken place even in such basins, that the margins have often a different mineralogical and chemical constitution from the more central portion, and that the differences are greater than can be accounted for by solution of the enclosing rock, and are often of a chemical nature which cannot be so explained.

The various theories that have been propounded fall into two distinct classes—those which seek the cause in the separation of solid material from the liquid, so that when the latter subsequently crystallised it constituted a different rock from the former; and those theories which assume that different liquids have separated from each other and then solidified as different rocks.

The first conception satisfactorily explains the manner in which the least soluble minerals are concentrated at the bottom or margin of an igneous mass, for they naturally crystallise first where the mass is coolest, or where contact with other crystals may have occurred; or even if they have been precipitated as a cloud throughout the magma they must be carried about by convection currents and ultimately sink together unless the magma be very viscous. Most geologists will probably agree with the conclusions of Vogt that some of the most important deposits of metals, metallic oxides, and sulphides have been produced by magmatic differentiation from deep-seated magmas which now constitute basic rocks associated with them. But this does not explain how the mass which has crystallised out may be not a mineral but a rock.

The actual observations on crystallising solutions do not amount to much; it is quite clear from laboratory experiments that crystals do grow by means of convection currents, which produce a flow of stronger solution towards the crystal and of weaker and warmer solution upwards and away from the crystal. The concentration currents can easily be seen in any ordinary aqueous solution as

streaks in the liquid. Again, that there might be a slight difference in the concentration of the upper and lower, or of the warmer and cooler parts of a solution has also been shown. That a very considerable difference in concentration can be produced by centrifugal action was proved only last year by the experiments of Calcar and de Bruyn, in which solutions contained in rapidly rotating vessels became more concentrated in the portions furthest from the axis of rotation.

Schweig has recently suggested that the crystals which fall to the bottom of a rock-magma may be unstable compounds, which redissolve when the pressure is relieved, and so give rise to an underlying magma of different chemical constitution.

Harker, also, some time ago, suggested the existence of horizontal layers of different liquid magmas above each other, thus attempting to explain the presence of quartz in basic rocks as due to the crystals which had sunk into the basic magma from a more acid magma floating upon it.

The second theory, that of liquid differentiation, regards such layers as actually produced by the spontaneous division of a magma into two liquids of different composition, and if it be tenable seems more capable of explaining the geological facts.

The experiments bearing on the subject are well known, and have been quoted by Bäckstrom and Teall; mixtures of phenol and water, or of aniline and water, which form a homogeneous solution above a certain temperature, may below that temperature (which is a sort of critical point of the solution) divide into two solutions, one consisting of phenol in excess of water, the other of water in excess of phenol; and these two solutions are not miscible, but separate into two distinct layers.

Many pairs of substances have now been found to exhibit this incomplete miscibility, which varies with the temperature and may at certain temperatures become complete; among them are some of the metals such as zinc, lead, bismuth, and silver.

If rock-magmas can really behave in this way, there is no difficulty in explaining their differentiation; but experiments upon fused silicates have not disclosed anything of the sort, though they are made far below the critical temperature.

The case of nicotine and water, which has recently been described by Hudson, is remarkable and suggestive: above a temperature of 205° a mixture in equal proportions is a clear liquid; at 205° it divides into a saturated solution of nicotine in water floating on a saturated solution of water in nicotine; at 90° these two layers change places; at 64° they mix again and the liquid becomes once more homogeneous.

It is, of course, possible that fused silicates at experimental temperatures correspond to nicotine and water below 64°, and that rock-magmas correspond to the same mixture at higher temperatures.

In discussing the reasons why in laccolites of the Square Butte type the margin should be more basic, and in laccolites of the Magnet Cove type more acid than the centre, Washington regards the magma as a mutual solution of an alumo-alkaline substance with a ferro-magnesian substance; whichever of these is in excess may be regarded as solvent, and crystallises first, for example, either the syenite or the shonkinite. In a laccolite where no differentiation has taken place, as in the Henry Mountains type, he supposes the mixture to be eutectic or such that they crystallise together. Pirsson, in a paper recently published upon the 'Highwood Mountain Laccolites of Montana,' while attributing a greater part in the process to the action of convection currents, also regards the ferro-magnesian minerals, taken together, as constituting the solvent and crystallising first as shonkinite.

In fact, stated quite baldly, these latest views tend to a compromise between the two theories which I have just mentioned. They regard the splitting of the magma as produced by a fractional crystallisation, only now the mass which crystallises is not a mineral but a rock; in other words, they assume that rocks may be dissolved in each other, and may crystallise from each other as though they were minerals.

In this matter of magmatic differentiation, then, there has been during the last few years a large accumulation of geological evidence, a little new speculation, but practically no new experimental work, and scarcely any progress.

Mineral Differentiation and Eutectics.

Let us pass to the second petrographical problem, that of mineral differentiation, the nature and order of the minerals which crystallise when a cooling magma becomes a solid rock mass.

It has been laid down by Rosenbusch, and is accepted as a general rule (in spite of many exceptions), that the order in which the various minerals crystallise is one of increasing acidity, ores and oxides and so-called accessory minerals first, then those minerals which are comparatively poor in silica, then those which are richer, and finally, if it be present in excess, the silica itself. It has also been supposed that the order may be one of the fusibility of the various minerals under the conditions of their formation; the least fusible minerals being the earliest to crystallise, and the most fusible the latest. Interesting speculations concerning the melting-point of quartz at high pressures, and its consequent order of crystallisation, have, for example, been published recently by Stromeyer and Cunningham.

It is not necessary, however, to regard the molten magma as a mere mixture of fused minerals which solidify more or less independently and consecutively; it is more reasonable to regard the whole magma as a solution in which the various minerals are dissolved, and from which they crystallise as it cools. Now the temperature at which a substance separates from solution is generally far below its melting-point, and the order in which the constituents of a mixed solution will crystallise is the order of their solubility in it, and bears no direct relation to their fusibility or to their chemical composition.

Teall in 1901, after discussing the controversies and the evidence on which they are based, came to the conclusion that rock-magmas are solutions, and that the order in which the minerals consolidate depends upon the nature of the constituents and their properties, and is not by any means the order of their freezing-points. As to the particular minerals which crystallise, he thought that the molecular grouping in the magma is determined by mass action and by the mutual affinities of the bases, the silica, and the alumina. Concerning future research he ventured to predict that the next advances were to be made by experiment controlled by the modern theory of solutions.

Thirteen years earlier Teall had himself contributed a valuable suggestion based upon Guthrie's work on cryo-hydrates. When a mixture of nitrate of lead and nitre is fused and allowed to cool, the constituent which is in excess will crystallise out as from a solvent until the proportions left in the liquid state are 47 of lead-nitrate to 53 of nitre, and this mixture will then solidify at 207°, not as a uniform compound, but as an intimate mixture of the two salts, the *eutectic*, which crystallises at the lowest possible temperature, and is the only mixture which has exactly the same composition as the liquid from which it solidifies. Teall made the illuminating suggestion that micropegmatite is an eutectic consisting of quartz and felspar, and represents in certain rocks the final mother-liquor from which the other minerals have crystallised out. Eutectics in metallic alloys have been much studied during recent years: in the Address of 1901 Teall was able to strengthen his case by showing that spherulitic and micropegmatitic structures found in obsidian and other acid rocks are paralleled by similar structures developed in eutectic alloys, according as they have been rapidly or slowly cooled.

In the following year appeared a theoretical paper by Meyerhoffer concerning the ideal case of a molten mixture of two substances, *a* and *b*, which do not suffer double decomposition, nor form a double salt, nor an isomorphous mixture.

Let a diagram be constructed, with temperatures as ordinates and composition of the magma as abscissæ, giving by a curve the nature of the magma which is in equilibrium with either solid *a* or solid *b*. The curve has the form of a V; one

arm represents the temperature and constitution of the liquid which can be in equilibrium with a, and the other that of the liquid which can be in equilibrium with b; and the lowest point corresponds to the eutectic, which is in contact with both.

Let a point above the curve represent the temperature and constitution of the liquid magma containing excess of b; as the magma cools this point descends to the b branch and travels along it while b is crystallising out, until the eutectic point is reached, when a and b both crystallise out together at a temperature below the melting-point of either. The order of crystallisation is therefore determined solely by the composition of the magma as compared with that of the eutectic. If, however, the liquid be cooled slowly, crystallisation may be postponed until it has become supersaturated with regard to one constituent or the other, or both; a state of affairs represented by a prolongation of the arms of the V below its lowest point, and then the order of the crystallisation may be inverted.

In a rock-magma there are of course many other factors to be taken into account as determining the order in which the minerals separate; for example, the formation of both double salts and isomorphous mixtures, the possible production of unstable solid compounds which may become converted into stable compounds or may be redissolved soon after they have come into existence; and also the relative velocities of crystallisation, changes of temperature and pressure, action of steam, &c.; but the principle laid down by Meyerhoffer must be that which controls the process.

It might be objected that on this hypothesis the consolidation of every rock-mass ought to terminate with a eutectic mixture, whereas this appears to be by no means the case; in fact, it is only among some acid rocks that structures much resembling the eutectic mixtures of alloys are to be found. On the other hand, if the conditions of cooling are such that the magma becomes supersaturated with one mineral after another, it will overshoot the eutectic composition before each crystallises, and the final consolidation may be a well-marked sequence instead of a simultaneous crystallisation.

The controversies which have raged concerning the classification of rocks and their nomenclature appear to me to contribute little to the real advancement of knowledge. There are, I think, two more profitable lines of research which should accompany each other. We may take the facts as we find them and endeavour to explain them by the known laws of solutions aided by the phase-rule, provided that we have good reason to believe that rock-magmas behave like solutions, and we may make experiments upon slags and fused silicates and ascertain how far they resemble natural rocks in their behaviour and their mineral constitution. Some of the workers in this field have been led to regard rock-magmas as undoubtedly similar to ordinary solutions; others hesitate to seek an explanation for their features in the laws which govern the solutions studied in the laboratory. The two views are represented in the persons of the two men whose names are most closely identified with recent experiments, Vogt of Christiania and Doelter of Graz.

Doelter's Work on Melting-Points and Solubilities.

The labours of Doelter and his pupils have been largely devoted to the melting-points of the rock-forming minerals and their solubility in silicate magmas. From experiments upon these minerals and their mixtures they have come to the conclusion that in many cases the melting-point of the mixture is about the mean of the melting-points of the constituents, and that in such cases, therefore, there is no evidence that the freezing-point is lowered, or that a eutectic mixture is formed; so that it is not safe to apply the theory of cryo-hydrates to fused mixtures of silicates.

Doelter is therefore led to regard the silicate-magmas rather as mixtures of various constituents which may be dissolved in each other, but which are not by any means necessarily identical with the minerals which separate on cooling. The whole process seems to him to be far too complicated to be explained by any such

simple principle as the mere relative proportions of the various constituents to each other and to their eutectic mixture; the order of crystallisation must be determined by a number of factors, such as temperature, velocity of crystallisation, the interval between the softening and fusing of each mineral (which he finds to be considerable), viscosity, capillarity, the presence of water and mineralising agents, and the absorption of adjacent rocks.

To choose a simple example: minerals such as zircon, corundum, and titanite separate for the most part early, because they are less soluble. On the other hand, magnetite is one of the more soluble minerals, and yet it is one of the first to separate; the same is to a certain extent true of augite, but not always. It is possible that in a magma which still contains the iron of the magnetite in solution plagioclase and augite may be comparatively soluble and magnetite comparatively insoluble, but that when magnetite has already crystallised out from the magma the plagioclase and augite may be comparatively insoluble; the experiments which are wanted are experiments upon the solubility of certain minerals in magmas of known composition under known conditions; in these and similar instances the order of separation is that of the solubility, but such physical factors as the velocity of crystallisation (which varies very considerably with the temperature), and the viscosity, may completely invert the order.

Direct experiments made by Barus and Iddings upon the electric conductivity of silicate magmas afford evidence that such magmas contain dissociated as well as undissociated molecules, so that they cannot be regarded as merely fused mixtures of certain minerals. If two or more rock-forming minerals be fused together it may happen that they form new compounds and crystallise out as different minerals, or if one or the other remains unchanged it may crystallise out in a different proportion. All this shows that double decomposition goes on in the liquid. We cannot therefore expect, without knowing the degree of dissociation, to make much use of the lowering of the freezing-point in order to calculate the other factors in the process of rock-formation.

Doelter concludes that upon the whole the normal order of crystallisation in rocks is in the main that laid down by Rosenbusch long ago, namely, an order of increasing acidity, but that it is determined by the mutual affinities of the molecules in the magma, and by the relative power of crystallisation of the components into which they unite themselves, and that the physical factors which I have already enumerated play a very important part in the process. No one has endeavoured more systematically than Doelter to determine for the rock-forming minerals the melting-points and the solubilities, without which it is impossible to make much progress in our reconstruction of the history of rocks. He has recently shown us how the microscope may be used in the study of fused silicates at high temperatures, and has so opened up a new field of research.

Vogt's Applications of the Laws of Solutions.

The work of Vogt has extended over many years, and is now summarised in two remarkable memoirs recently published by him, in which are expressed his mature opinions upon silicate magmas; the reasoning is based upon his own experiments, upon those of Doelter, and upon the classic researches of Åkerman. It is now generally conceded that the particular minerals produced in a silicate magma depend much more upon the chemical composition of the magma than upon temperature and pressure; Lagorio and Morozewicz were led to this conclusion by their own experiments upon fused silicates. Experiments upon slags at ordinary temperatures and pressures may, therefore, be invoked to elucidate the formation of rocks.

In 1902 Vogt stated his conviction that the laws of solutions may be applied to igneous rocks, and his two recent memoirs are, in fact, an attempt to explain the experiments upon slags and fused silicates as examples of the operation of these laws.

All important, according to him, is the composition of the eutectic mixture; he finds that if the analyses of silicate magmas be arranged according to their

oxygen ratio or acidity, the various minerals of which they consist make their appearance within fairly well-defined limits. For example, in the case of the Ca-Mg-Fe-Mn slags, which contain little alumina, olivine and the melilite minerals only make their appearance in the more basic slags, and the meta-silicates in the more acid, the limit between the two corresponding to an acidity of about 1·6.

The limit of individualisation between the various minerals is supposed to correspond to their eutectic mixture. Such slags may, therefore, be regarded as a mutual solution of two or more of the minerals olivine, enstatite, hypersthene, augite, the gehlenite-melilite group, akermanite, wollastonite, and the hexagonal metasilicate, which is so characteristic of the more acid slags. The particular minerals which make their appearance are practically determined by the acidity of the magma and by the relative proportion of the bases present, particularly by the ratio of the calcium to the magnesium-iron-manganese group; in other words Vogt asserts that a silicate magma is a mutual solution of the various crystalline compounds that actually make their appearance as it solidifies, and that the order of crystallisation depends upon their proportion in the magma as compared with their proportion in the eutectic. The old conception of a solvent and a solute ceases to have much meaning; the matter which is of supreme importance is the nature of the eutectic mixture when the constituents are given; thus micro-pegmatite and microfelsite represent the eutectic of felspar and quartz, and correspond to a mixture of about 74 parts of felspar to 26 of quartz, as indeed has been stated by Teall.

Now, if we are justified in regarding rock-magmas and fused silicates as mutual solutions of certain definite compounds, and if these compounds are actual minerals or other silicates which crystallise out of the magma when it cools, we are also justified in making use of the properties of these minerals when we apply to the magma the known physico-chemical laws which govern solutions.

The number and nature of the minerals which can be in equilibrium with each other and the solution are to be determined by experiments upon their solubility interpreted by the phase-rule of Willard Gibbs, and especially by the laws which Roozeboom and other physical chemists have deduced for components which form double salts or isomorphous mixtures. Knowing the components we ought, therefore, to be able to determine their latent heat of fusion, their specific heat, the lowering of the freezing-point of their mixtures, and from these data to calculate the true formulæ of the rock-forming minerals. It will readily be understood that in a mixture of quartz and orthoclase, the lowering of the freezing-point below that of either of the constituents, as calculated by van 't Hoff's formula, from their melting-points, latent heats, and molecular weights, will be very different according as the formula of quartz is taken to be SiO_2 or Si_3O_6.

Vogt boldly attacks the whole problem as one that can be solved on these lines: we have good reason to believe that the slags and rock-magmas are solutions; we know their constituents; we can therefore proceed to experiment with these constituents and to predict the behaviour of their mixture according to the principles of physical chemistry. The order of crystallisation is mainly determined by the relative composition of the magma and the eutectic, and the composition of the eutectic may be calculated from the intersection of the freezing-curves.

One interesting result is the conclusion that in the silicate magmas which have been the subject of experiment the minerals produced are all of very simple constitution; that, for example, olivine, diopside, akermanite, melilite, and anorthite have the simplest possible formulæ corresponding to their analyses and are not polymerised. Mineralogists will welcome this conclusion if it be true, for it has occasionally been the fashion on theoretical grounds to attribute a high degree of polymerisation to many minerals, and nothing is easier than to account for many difficulties if one may multiply the formula of a mineral by any number that is required. It should be added, however, that Doelter, calculating from his own experiments, is led to think that some of the minerals must have formulæ which are multiples of their empirical formulæ.

Vogt even goes a step further in his application of the principles of modern chemistry. The order of crystallisation appears to be by no means always that of the solubility, but indicates that a mineral is sometimes not so soluble as might be supposed. Now another principle in the modern physics of solutions is that by adding to a solution of one substance a new electrolyte containing an ion common to both the solubility of the first is diminished, and Vogt does not hesitate to apply this principle.

Thus spinel and felspar in mutual solution, when felspar is in large excess, should on cooling yield felspar first. But in many basic rocks spinel is the first to crystallise; this is, according to Vogt, due to the presence of ferro-magnesian silicates containing the Mg-ion which is also present in spinel; if these be partially dissociated the solubility of the aluminate will be lowered.

An obvious criticism on this argument is that if the dissociation is so slight that it may be ignored for one purpose, it is hardly fair to invoke its powerful action for another, and it is possible that Vogt in his enthusiasm for a theory attempts to explain too much by its aid.

It is clear, however, that the labours of Vogt have been precisely in the direction indicated by Teall in the words that I have quoted, 'experiment controlled by the modern theory of solution'; and if his opponents are tempted to think that he may have carried the principle too far with insufficient data, they cannot but admire the brilliancy, the persistency, and the ingenuity with which he has applied the newer theories of solution at every turn.

Heycock and Neville's Work on Alloys.

I must next refer briefly to another remarkable series of researches which have recently been published.

The laws which govern the solutions of metals in metals, that is to say alloys, appear to be the same as those which prevail in the case of other solutions; it is in alloys that the nature of eutectic mixtures has been most fully studied; and the phase-rule and Roozeboom's deductions from it have been applied with signal success to their investigation. A new impulse has been given to the subject by the work of Heycock and Neville which is summarised in their Bakerian lecture delivered last year upon the copper-tin series of alloys. They have studied the changes which occur during the cooling of an alloy by taking small ingots of the cooling metal and chilling them at certain temperatures; this arrests the gradual process of cooling and causes all that is liquid at the moment of chilling to become suddenly solid; it is then possible by polishing and etching the ingot to show the solid crystals set in the congealed ground-mass and to study their nature. They have been able to interpret their results by means of Roozeboom's remarkable work on the solidification of mixed crystals published in 1899. For our present purpose it is sufficient to consider these results as applied only to alloys. If a diagram be constructed with the temperatures for ordinates and constitution for abscissæ, Roozeboom has shown that two curves may be drawn. The first is the freezing-point curve, or *liquidus,* giving the temperatures at which an alloy of any composition begins to solidify: this is a broken curve and each section of it represents the temperature of equilibrium between the liquid and a different solid alloy; the breaks represent the temperatures and constitution of the liquid at which one solid ceases to be produced and another begins. The curve is, of course, far more complicated than the simple V of Meyerhoffer, since that represents the cooling of a mixture whose constituents do not form compounds or isomorphous mixtures, whereas the alloys do both. In this respect the alloys resemble a silicate magma which is crystallising as a rock-mass; indeed it will be remembered that Mendeléef insists upon the general similarity of silicon compounds to metallic alloys.

The second curve of Roozeboom is the melting-point curve, or *solidus,* representing the temperatures at which an alloy of given composition becomes completely solid. Points above the liquidus represent the condition of alloys which are completely liquid; points below the solidus that of alloys which are completely solid; points between the two that of cooling alloys which are only partially solid;

and the curves themselves show which solid compounds can be in equilibrium with the liquid and with each other at any temperature.

The cooling-curves of Roberts-Austen and Stansfield had shown that considerable evolutions of heat may occur in cooling alloys far below the temperature of solidification, indicating that changes are going on in the solid as well as in the liquid condition. Heycock and Neville carry their investigations below the temperature of complete solidification and study these changes also.

In the case of the copper-tin series of alloys they find that, according to the temperature and constitution of the liquid, crystals belonging to no less than six different types may separate, namely:—

- α, a solid solution of Cu with less than 9 per cent. of Sn.
- β, a solid solution of Cu with less than 27 per cent. of Sn.
- γ, of which the constitution is not known.
- δ, which probably has the composition Cu_4Sn.
- η, which probably has the composition Cu_3Sn.
- H, which probably has the composition CuSn.

Both β and γ are unstable at ordinary temperatures. The compound δ crystallises out of β or γ while they are already in the solid state, when the temperature falls sufficiently.

A glance through the 101 photographs of chilled and etched ingots which accompany Heycock and Neville's paper on this series of alloys shows how impossible it would be from the final composition of the solid alloy to ascertain the various stages through which it has passed during cooling; as the authors remark, it is of the nature of a palimpsest. For example, the alloy, containing 14 atoms of tin to 86 of copper, consists at 800° of α crystals in a ground-mass which probably contains β; it solidifies at about 775°; at 675° there are only β crystals; at 600° there are α and β crystals, but here α has crystallised out of β after it became solid; at 530° there is a much larger proportion of α; at 470° there are α crystals immersed in a mixture of α and δ into which the residual β has broken up on cooling.

If the course of events is so complex in an alloy of only two metals, how much more difficult must it be to decipher in the case of a mass of complicated silicates which are even more prone to form isomorphous mixtures, such as we have in a solid rock, not to mention the additional presence of aluminates, oxides, and sulphides. And yet geologists are accustomed to speculate freely about the crystallisation of rock constituents from the magma without taking account of anything save the final stage.

I cannot help thinking that the experimental method of Heycock and Neville will have to be applied to the study of slags and fused silicates if we are to trace successfully the evolution of rock species. The value of their work to geologists is not only that the results are skilfully interpreted by the light of modern physical chemistry, but primarily that it is experimental work upon actual crystallising materials.

Supersaturated Solutions.

I do not myself see how we can do otherwise than apply to the study of rock-magmas all that can be learnt from physical chemists concerning the behaviour of solutions, for though we cannot attain in laboratory experiments the high temperatures and great pressures at which rocks may have crystallised, there is no reason to believe that these introduce more than a difference of degree. The principles of equilibrium between the various crystallising components probably remain the same, whatever may be the temperatures and pressures at which they have solidified.

It must at the same time be confessed that most of the experiments upon which the modern theory of solutions has been built up have been conducted upon dilute solutions, whereas the problems of crystalline growth are concerned, not with dilute nor even with saturated solutions, but only with solutions which are supersaturated. There is some force in the objection of Doelter that the results of such experiments may not be directly applicable to crystallising slags.

For example, as I have already mentioned, doubt has been expressed in the case of silicate magmas, whether the substances in solution are the minerals about to crystallise or only their constituents; whether viscosity and supersaturation may not invert the theoretical order of their appearance; whether we are to take into account possible dissociation of the molecules or not; whether the presence of a common ion in these minerals is a factor which determines their mutual solubility. In fact, very little is known about the actual condition of the materials in a strong solution, although I do not know that there is any evidence available which forbids us to regard a solution about to crystallise as a mixture of liquids one of which is about to pass into the solid state.

But if little is known about the nature of strong and supersaturated solutions, a good deal may be learnt about their behaviour. Having complained that we need experiments in this field, I may perhaps be pardoned if I allude to some unpublished experiments of my own which relate to the general behaviour of crystallising liquids, and appear to me to explain two difficult problems in petrography. To such experiments the objection of Doelter does not apply.

The Metastable and Labile Conditions.

When a solution of any salt such as alum or sodium nitrate is allowed to crystallise at a uniform temperature the crystals will only grow so long as the solution is supersaturated; a crystal growing in the supersaturated solution will continue to do so until a condition of equilibrium is attained. If the solution be kept at rest and maintained at a constant temperature, the crystal will continue to concentrate the liquid around itself and to withdraw solid material, until by diffusion of the impoverished liquid the whole mass is ultimately reduced to saturation, equilibrium is established, and the crystal ceases to grow; but most saturated solutions are so viscous that a very long time is required before this point is reached. Prolonged and vigorous stirring is required if the supersaturation is to be completely relieved within, say, a day; without stirring weeks may be required.

Further, it may be possible, as is well known, to keep a supersaturated solution in a sealed tube for years without change; and it is also possible to start crystallisation in such a liquid by dropping into it a crystal of the dissolved substance, or of one isomorphous with it, or sometimes by shaking it.

But it is, perhaps, not generally known that supersaturated solutions are of two sorts.

In 1897 Ostwald published some experiments upon supercooled liquids and supersaturated solutions, which were carried out with the object of showing how extraordinarily minute are the quantities of solid material capable of starting crystallisation in such liquids, but at the same time that they have a limit of size. He called attention to the radical difference which probably exists between the state of a saturated solution which cannot crystallise spontaneously and that of the more strongly supersaturated solution which can do so.

The former is one in which crystallisation can either take place spontaneously or can be induced by stirring or shaking, or a variety of causes: this Ostwald calls the *labile* state. The latter is one in which crystallisation can only take place if a solid crystal of the dissolved substance, or a fragment of one, is brought into contact with the liquid: this he calls the *metastable* state. It is highly probable that no amount of stirring or shaking, or introduction of foreign substances, can make the metastable liquid crystallise.

Until recently no attempt to ascertain the exact limit between the metastable and labile states, or even to establish the existence of such a limit, had been successful, and practically no attention has been paid to the difference between them. Tamman, who measures the spontaneous power of crystallisation by counting the number of the centres of growth or nuclei which appear in a supersaturated solution, does not recognise any distinction between the two states.

During the present year a number of experiments carried on by Miss F. Isaac and myself upon the strength of solutions from which crystals are growing have

shown that it is easy to determine the changing concentration of a cooling solution by an optical method, to show that it passes into the labile state, and to ascertain the temperature at which the transition occurs. We have found, for example, that a solution containing 48 per cent. of $NaNO_3$ is saturated at 26°, is metastable between 26° and 16°, and crystallises spontaneously below that temperature; one containing 52 per cent. of $NaNO_3$ is saturated at 44°, and becomes labile at 35°.

In the metastable state inoculation by a solid germ of the dissolved substance, or of one isomorphous with it, is *necessary* in order to cause the liquid to crystallise; in the labile condition solid germs may be spontaneously generated from the liquid. Take, for example, a test tube filled with a solution of sodium nitrate containing 48 parts of the salt in 100 parts of solution, which is metastable at ordinary temperatures; if crystals make their appearance in this solution it will only be because the dust of the room contains minute particles of sodium nitrate which fall into the tube, or because crystals are deposited where drops have evaporated near the surface, and accordingly the first crystals appear at the surface of the liquid, and grow there until they are large enough to fall to the bottom. I find that such a solution, if enclosed in a sealed tube so as to prevent access of germs and evaporation, cannot be made to crystallise above the temperature of 16°, although it is supersaturated at all temperatures below 26°.

Again, let a hot solution of the same strength containing 48 per cent. of the salt be allowed to cool down while being stirred. If dust containing $NaNO_3$ can be excluded, the liquid will not crystallise until the temperature falls to 16°, when the solution passes from the metastable to the labile condition. A cloud of nuclei will then form throughout the liquid, and each will proceed to grow as a separate crystal; the immediate effect is to reduce the liquid to the metastable state so that no more crystals are produced, but each of these continues to grow from the liquid with which it is in contact.

If dust be not excluded, crystals may make their appearance upon the surface of the liquid and will soon sink; but even though they be stirred about actively in the solution the liquid as a whole remains in the metastable state till a temperature somewhat below 16° is reached, when the labile region is entered and a cloud of new crystals makes its appearance.

It follows, therefore, that in a cooling supersaturated solution, from which germs have not been excluded, there are normally two periods of growth: one in which a comparatively small number of isolated crystals are growing regularly, and a subsequent period in which a shower of small crystals is produced. Only if the rate of cooling be sufficiently slow, or the stirring be sufficiently violent, to keep the liquid in the metastable condition will there be no second period, no sudden precipitation of nuclei.

These events take place in all the aqueous solutions which I have examined, and I am surprised that they have not been discovered before. They afford a possible explanation of two common features of igneous rocks, and of slags—namely, the growth of comparatively large and isolated porphyritic crystals, or phenocrysts, and the appearance of the same mineral at two or more different periods. The origin and the arrested growth of phenocrysts have generally been attributed to sudden change of temperature, of pressure, or of hydration, and no other plausible explanation has been given, although, as has been sometimes pointed out, they may occur in batholites where there is no independent evidence of such changes. Pirsson has recognised the utter impossibility of the ordinary theory and has recently suggested that each mineral has its crystallisation interval during which it continues to grow, and that this is terminated by the increasing viscosity of the magma, which checks the supply of further material to the growing phenocrysts and establishes new centres of crystallisation. A similar explanation was adopted by Crosby for the quartz-porphyry of the Blue Hills. He expresses it by saying that owing to the increased viscosity the rate of cooling overtaxes the molecular flow, which cannot keep pace with the crystallisation. It is so difficult to find any satisfactory theory for the growth of phenocrysts that they have even been attributed to the effect of earthquake shocks.

Now in a silicate magma, in all probability, the temperature is sufficiently high

to be that of the metastable condition, the rate of cooling sufficiently slow to keep the liquid in that condition for a considerable time, and the viscosity sufficiently great to prevent the growing crystals from sinking at once; we have, therefore, all the conditions favourable for the growth of *porphyritic* crystals; these must have generally originated throughout the liquid as spontaneous nuclei if the magma entered the labile state, or may have been started by inoculation or cooling at the margin if the magma as a whole remained in the metastable state. In the latter case suppose that further somewhat sudden cooling brings the magma to the labile condition, then there will be a sudden and spontaneous second growth of nuclei which will not be able to attain the dimensions of the porphyritic crystals; we have here all the conditions necessary for a *second generation* of one of the constituents of the rock.

It is not necessary, therefore, to suppose that changes of pressure played any very great part in these matters. I believe it will be found that considerations of temperature and solubility are far more important. Similarly in the case of the salt deposits van 't Hoff came to the conclusion that practically the only effect of changes of pressure is to displace the temperature of formation of the various compounds and not to alter their order or their nature; he estimates that this displacement is comparable with that of the melting-points under the same agency, and in the case of the calcium-magnesium chlorides only amounts to a few thousandths of a degree for one atmosphere of pressure.

Perhaps when we can ascertain the temperature at which silicate magmas pass from the metastable to the labile condition we may use this knowledge to determine the exact temperature at which certain of their minerals crystallised.

Ordinary petrographical descriptions supply numerous examples of the difference between the metastable and labile conditions to anyone who will read them in the light of the suggestion which I have made; others are to be found in such experiments as those of Vogt or Doelter.

My own hope is that when more experiments have been made upon mixed *supersaturated* solutions it will be found that most, if not all, of the features of rock development are parallelled by the ordinary processes of crystallisation, but that motion, supersaturation, and supercooling are most important factors.

The very similarity between the differentiation of the alumo-alkaline and ferro-magnesian minerals on a small scale in the rock, and that of the alumo-alkaline (or salic) and ferro-magnesian (or femic) rocks themselves on a large scale, points to some similarity of origin.

In order to avoid burdening this address with detail I have merely chosen the researches of van 't Hoff, Vogt, Doelter, and Heycock and Neville as illustrations of experimental work conducted on the lines of modern physical chemistry, and have omitted much that might have been mentioned; the valuable researches of Pelouze, Lagorio, Morozewicz, and Loevinson-Lessing, and the melting-point determinations of Joly I have not quoted, because they belong for the most part to an earlier period than that which I am considering, and have been discussed by Teall and other writers.

Many very interesting speculations I have passed over entirely, because my object has been to focus attention upon experimental evidence. I cannot help thinking that these speculations are often based upon chemical actions and equilibria that may be impossible; but we cannot criticise them for lack of evidence, and I return to my original statement that geology is only beginning to enter the experimental stage.

An earnest beginning is, however, being made. The researches on mineral and rock synthesis which I have already quoted are laying a solid foundation; and I see no reason why something of the sort which has been done by van 't Hoff and his collaborators for the aqueous deposits of Stassfurt should not ultimately be worked out for an igneous complex, though it may involve tenfold the labour and tenfold the time. We have already to welcome the establishment by the United States Geological Survey of a laboratory for the express purpose of applying to minerals and rocks the exact methods of modern physics and physical chemistry. The very suggestive research of Day and Allen upon the thermal properties of the

felspars is a promise of the sort of work that may be expected from such laboratories.

I fear it will be only too evident to those who have given me their patience during this Address that I approach the problems considered in it from the point of view, not of the geologist or the chemist, but of the crystallographer, to whom the birth and growth of crystals are a study in themselves. Whether we watch with the microscope a tiny crystal growing from a drop of solution, or contemplate with the imagination the stages by which the fiery lavas of past geological periods sank to rest and crystallised, we view the same process; it is the transformation of liquid into crystal. Not necessarily into a solid, for recent research shows that there is no dividing line between liquid and solid; a plastic solid body may flow; a solid glass is only a supercooled liquid; witness, for example, the experiments of Adams on rocks, and of Tamman on supercooled liquids. The real primary distinction is between crystalline and non-crystalline material, and there is even good reason to believe that some crystals are liquid without ceasing to be crystals.

The properties of most rocks, of metals, alloys, ice, and many other substances are due to the fact that they consist of crystals, and the importance of the study of the latter is now, I trust, being brought home alike to chemists, physicists, geologists, and engineers in connection with problems relating to the strength, the movements, the origin and changes of what are usually called solids.

And so I close, as befits a student and teacher of crystallography, with the hope that renewed attention may be paid to this subject, and that it may attract the interest of many a keen intellect in South Africa. The higher scientific studies are now establishing themselves as an integral part of the educational and intellectual life of the country: this is in no small measure due to the South African Association; and we may hope that the visit of the British Association will be of some help to her younger sister in the task of diffusing a taste and an interest for the pure truths of science and the studies that they both hold dear.

CAPE TOWN.

WEDNESDAY, AUGUST 16.

The following Papers and Reports were read:—

1. *The Geology of Cape Colony.* *By* A. W. Rogers, *M.A.*

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2. *The Classification of the Karroo Beds of South Africa.* *By* R. Broom, *M.D.*, *D.Sc.*

An attempt is made from the study of fossil remains to give a more satisfactory sub-division of the Karroo System than has hitherto been possible. The larger sub-division into the Dwyka, Ecca, Beaufort, and Stormberg Series is tentatively retained.

The Beaufort Series is divided into three parts. The lowest series is characterised by the presence of Therocephalians and Anomodonts. These lower beds can be again sub-divided into an earlier series, in which occur *Pareiasaurus* and *Titanosuchus*, a middle series characterised by the prevalence of *Dicynodon* and *Oudenodon*, and an upper characterised by the presence of *Kistecephalus*.

Above the Lower Beaufort Beds occurs a Middle series, characterised by the rarity of reptilian remains other than of *Lystrosaurus*, which is very abundant.

The Upper Beaufort Beds are characterised by the presence of the Cynodonts. In the earlier sub-division of these upper beds *Procolophon* is the most characteristic fossil, and in the upper the Cynodont *Cynognathus*.

The Stormberg Beds appear to be divisible into two groups—a lower, the

Molteno Beds, and an upper, which includes the Red Beds, the Cave Sandstone, and the Volcanic group.

The Dwyka and Ecca Series are considered to represent the Lower and Middle Permian of Europe, and the Lower Beaufort Beds the Upper Permian.

The Middle Beaufort and Upper Beaufort Beds are believed to correspond to the Lower and Upper Trias of Europe.

The Lower Stormberg Beds are believed to be Rhætic, and the Upper Stormberg Beds Lower Jurassic.

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3. *The Continent of Africa in relation to the Physical History of the Earth.*[1] *By* Professor W. J. SOLLAS, *F.R.S.*

In accordance with the results obtained mathematically by J. H. Jeans ('Phil. Trans.,' 1903, A. 201, p. 157), the gradual evolution of the form of the earth and the distribution of the oceans may be supposed to have been somewhat as follows:

Soon after the birth of the moon the earth acquired a form like that of a pear, and so solidified. The aqueous atmosphere then condensed to form an ocean, which would be deepest round the neck of the pear. This ocean, which was the ancestor of the existing Pacific, formed a girdle round the globe, with a smaller continental mass in the middle on one side and a much larger continent (the present 'land hemisphere') on the other, forming respectively the stalked and broad ends of the pear. The land hemisphere then collapsed along an annulus, now represented by a part of the Atlantic, Mediterranean, and Indian Oceans, and leaving a bulging ring of land represented by North and South America, the Antarctic Continent, Australia, and Asia.

The centre of the mass of land at the broad end of the pear lies in the middle of Africa, which thus represents the remains of the primeval continent. This view is in harmony with the known absence of marine sediments over the greater part of the interior of Africa, notwithstanding the thick accumulations of flat-bedded strata existing there.

The smaller continent at the stalked end of the pear may have been represented by a tract of land formerly occupying part of the Pacific Ocean, for which some evidence exists.

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4. *Report on the Fauna and Flora of the Trias of the British Isles.*

See Reports, p. 161.

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5. *Report on the Erratic Blocks of the British Isles.*

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6. *Report on the Underground Waters of North-west Yorkshire.*

See Reports, p. 170.

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7 *Report on Life-Zones in the British Carboniferous Rocks.*

See Reports, p. 171.

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[1] See 'The Age of the Earth,' by W. J. Sollas (London: T. Fisher Unwin, 1905), pp. 44-64; and 'The Figure of the Earth,' *Q.J.G.S.*, 1903, vol. lix., p. 180.

THURSDAY, AUGUST 17.

Joint Meeting with Section E.

The following Papers were read:—

1. *The Physical Geography of Cape Colony. By* H. C. Schunke-Hollway.

To describe the physical geography of the Cape Colony in its relation to economic facts would be too great an undertaking. The writer therefore included only a few notes on the economic conditions.

The South African tableland occupies the greater part of the Cape Colony. We may divide the Colony into two parts—the Orange River Region and the Coast belt. The Coast belt, again, may be conveniently divided into (*a*) the Eastern Region; (*b*) the South-western Region, which very nearly coincides with the folded belt; (*c*) the Lower Karroo: (*d*) the North-west Coast Region. The watershed dividing the Coast belt from the Orange River basin is, for nearly three fourths of its length, over 4,000 feet above sea-level. The principal feature of the watershed is the main range of the Drakensbergen. The Eastern Region rises in two terraces of 1,500 to 2,000 feet and 4,000 to 4,500 feet altitude. The rate of denudation in this part has been comparatively slow on account of the presence of intrusive rocks. The South-western Region is totally different in its physical structure from the Eastern Region. It is a mountainous district, with ranges running more or less parallel to the coast. The rivers flow in longitudinal valleys between the ranges, and find their way seaward by deeply cut transverse gorges. The rivers of the Eastern and South-western Regions are all perennial streams. The best agricultural land is found in these regions. The remaining parts of the colony, with the exception of a fringe of land on their eastern side, belong to the desert region of South Africa, but offer much suitable land for pastoral purposes. The South-western and Eastern Regions have the greatest rainfall: the former gets its rains in winter, the latter in summer. Both these regions are also the most densely populated parts of the colony, and show the greatest percentage of cultivated land. It is, however, evident that the dominant occupation in the Cape Colony is stock-farming. In the South-western and Eastern Regions combined there are thirty districts which do not produce enough cereals for their own wants, although these regions are the chief agricultural areas of the colony. The richest districts are Paarl, Stellenbosch, Murraysburg, Victoria West, Barkly East. Taking into account the return from all sources, the Kimberley district is the richest of the Cape Colony.

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2. *Glacial Periods in South Africa. By* A. W. Rogers, *M.A.*

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3. *Changes of Climate as shown by Movements of the Snow-line and Upper Tree-limit since Tertiary Times.*[1] *By* Professor A. Penck.

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4. *The Sculpture of Mountains by Glaciers.*[1] *By* Professor W. M. Davis.

One method of determining whether glaciated mountains have been significantly eroded by the glaciers that once occupied them is as follows. Two alternative suppositions may be made: (1) glaciers can erode, (2) glaciers cannot erode. If the latter supposition be correct, then mountains shown to have been

[1] To be published in full in the *Geographical Journal.*

glaciated by the presence of striations ought not to present other features significantly unlike non-glaciated mountains; if the former supposition is correct, then glaciated mountains should present features significantly unlike those of non-glaciated mountains, and these features should be in form and distribution appropriate to glacial action. An appeal to the facts leaves no doubt in the minds of many observers that significant differences between the two classes of mountains certainly exist, and that they are of a kind that glaciers would produce if they could. Over-deepened main valleys with over-steepened walls, hanging lateral valleys, valley-head cirques, and exceptionally sharp ridges and peaks characterise strongly glaciated mountains, and are absent from non-glaciated mountains. These peculiar features, systematically associated, cannot be explained by normal non-glacial erosive agencies; nor can it be supposed that any special or exceptional agency can have produced them, for this supposition would require that the special agency selected in pre-glacial times all those mountains that were afterwards to be glaciated, and in a most systematic and prophetic manner worked upon them just as glaciers would work if they could, and then withdrew into obscure inactivity, where they remain undiscovered to this day. Such a supposition is absurd The evidence now in hand from the Alps, Norway, Alaska, the Rocky Mountains, the Tian Shan, New Zealand, and elsewhere is so abundant and consistent that it has in recent years led many observers to accept the belief that glaciers can erode, and that they have been effective agencies in the sculpture of certain mountain ranges, even though the processes of glacial erosion are not yet fully understood.

FRIDAY, AUGUST 18.

The following Papers and Report were read:—

1. *On a Subterranean Tide in the Karroo.* *By* Professor ANDREW YOUNG, *M.A.*, *B.Sc.*

This paper was of the nature of a first notice regarding an investigation which is in progress as to the nature of certain periodical variations in the rate of discharge of an artesian well in the Karroo, on a farm called 'Tarka Bridge.' The site of the well is over 2,700 feet above sea-level, and fully 100 miles from the coast.

The bore-hole is only 65 feet deep, but there is a large and regularly fluctuating artesian supply of water at a constant temperature of about 80° F. accompanied by a great quantity of inflammable gas.

A self-recording apparatus placed in a tank over the bore-hole has given continuous records for some few weeks. The record is a curve showing a series of waves of remarkable regularity, the average wave-length being within a few minutes of 12½ hours. A comparison of wave amplitudes shows a marked variation of the height of the waves, corresponding in time to the phases of the moon and analogous to the phenomena of marine spring and neap tides.

It was suggested that the water rises through a fissure-system from a depth of several thousand feet mainly under the influence of the pressure of natural gas, and that the tidal fluctuation is a minor lunar effect superimposed on the effect of fairly constant gas pressure.

A comparison of this tidal record with the barograph records obtained simultaneously, shows that variations of barometric pressure play a very insignificant part in the production of the variations of water-pressure in the bore-hole.

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2. *The Stormberg Formation in the Cape Colony.* *By* ALEX. L. DU TOIT, *B.A.*

The Stormberg Formation is the uppermost division of the Karroo System in South Africa, and builds up the whole of Basutoland and the adjoining portions of the Cape Colony, the Orange River Colony, and Natal. In the Cape Colony the

tract occupied by this formation is confined to the immediate neighbourhood of the Drakensberg Range, widening out considerably in the south-west over what is known as the Stormberg area.

The Stormberg series is subdivided as follows, in downward succession :—

(4) Volcanic Beds,
(3) Cave Sandstone,
(2) Red Beds,
(1) Molteno Beds.

The strata lie nearly horizontally, or are only inclined at low angles, consequently the lower divisions crop out along the foot of the mountain ranges, while the upper beds form all the higher ground. The Molteno Beds consist of a thickness of from 1,000–2,000 ft. of sandstones, with thin, dark shales and mudstones and occasional coal-seams. Arenaceous material is predominant, and the sandstones vary from fine-grained grey felspathic varieties to coarsely-crystalline 'glittering' sandstones, with small pebbles of vein-quartz. Boulders of hard white or brownish quartzite, derived evidently from the Cape Formation, are common, usually scattered irregularly throughout the sandstone beds, but occasionally forming conglomerate bands. The coals are thin, and contain from 15 to 30 per cent. of ash, but are the only workable deposits in the Cape Colony. Fossils are almost entirely those of plants, *e.g.*, *Thinnfeldia*, *Taeniopteris*, *Callipteridium*, &c., from which the Rhætic age of the beds has been deduced.

The Red Beds are more argillaceous in character, and consist of from 600–1,600 ft. of strata, in which red and purple shales, mudstones, and sandstones are predominant, though thick beds of fine-grained, white sandstone are also common. Fossil remains are chiefly those of carnivorous dinosaurs, such as *Euskelesaurus* and *Massospondylus*.

The Cave Sandstone is a thick bed of fine-grained felspathic sandstone, usually white or yellowish in colour, and of very striking appearance. As a rule, it is unbedded throughout, except towards its summit, or less commonly towards its base. In some places it attains a thickness of 800 ft., but as a rule it varies from 150 to 350 ft. In a few places the Cave Sandstone is entirely absent, and the volcanic beds rest directly upon the red beds. The Cave Sandstone weathers into most fantastic outlines, and gives rise to very peculiar scenery along the Drakensberg.

The sediments of the Karroo System were deposited in a great inland sea, 'the Karroo Lake,' in which the water was either fresh or slightly brackish, and not very deep. During the formation of the Stormberg rocks the shore-line stretched where the coast ranges of the south of the Colony now rise, and extended eastwards into the Indian Ocean, and then north-eastwards parallel to the coast-line of Natal. This old land surface was formed of rocks belonging to the Cape and Pre-Cape Systems, quartzites, granites, and metamorphic rocks.

During Cave Sandstone times volcanoes came into existence, and great eruptions of basic lavas took place. Over 100 volcanic necks have been mapped by the Geological Survey, some of which are over a mile in diameter. Many of the pipes are filled with siliceous breccias, or with fine-grained sandstone-like tuffs. The erupted material consists almost entirely of basic lavas, compact to vesicular, the most interesting variety of the latter being the 'pipe-amygdaloid'; enstatite-andesites occur in a few places. Beds of volcanic ash are met with in Barkly East and around Jamestown. In the former district there are frequent alternations of lava, ash, and sandstone, the even bedding and passage of sandstone into ash, either laterally or vertically, pointing conclusively to sub-aqueous eruptions. The later flows were probably sub-aerial.

At the close of the volcanic outbursts, after from 2,000–5,000 ft. of lavas had been erupted, the area was affected by gentle folds by which the direction of flow of the Kraai and Orange Rivers was determined. Then followed the gigantic and extensive intrusions of dolerite, which at the present day form such a conspicuous feature in the scenery of the Karroo.

The interior of the colony was intermittently elevated, and the old land surface

in the south disappeared beneath the waters of the Indian Ocean. A series of peneplains, or plains of river-erosion, mark the periods of rest and elevation of the country, the highest of which is now found at an altitude of a little over 8,000 ft. above sea-level. The plateau of the Drakensberg has been deeply cut into on the west and south-west, but on the south-east it presents an almost unbroken face, over 300 miles in length, rising from 2,000 to as much as 6,000 ft. above the ground at its base.

The following correlation with extra-African formations is suggested:—

	South Africa	India	New South Wales	Europe
Stormberg Formation	Volcanic Beds . Cave Sandstone	Rájmahál Series		Middle (?) and Lower Jurassic
	Red Beds . .	. . . . .	?	
	Molteno Beds	Kota - Maleri Series . .	Wianamatta Series . .	Rhætic
Beaufort Formation	Upper Beaufort	?		
	Burghersdorp Beds . . Middle Beaufort Beds	Pánchet Series, &c. . .	Hawkesbury Series, &c. .	Triassic, &c.

3. *Recent Advances in Seismology.* *By* JOHN MILNE, *F.R.S.*

4. *On the Geology of South Victoria Land.* *By* H. T. FERRAR, *M.A.*

I. The knowledge we had of South Victoria Land previous to the departure of the 'Discovery' was mainly acquired by the expedition under Sir James Clarke Ross in his ships, H.M.S. 'Erebus' and H.M.S. 'Terror,' in the years 1839–1843. His discoveries may be briefly summed up thus:—

(*a*) A great range of mountains, which rise occasionally to heights of 15,000 feet, and extend in a north and south direction for at least 500 miles.

(*b*) The presence of volcanic and plutonic rocks in this area.

(*c*) An open shallow sea south of the antarctic circle.

(*d*) An active volcano, Mount Erebus, over 12,000 feet high, 'emitting flame and smoke in great profusion.'

(*e*) A wall of ice, the Great Ice Barrier, on an average 150 feet high, and about 470 miles long.

In 1899 the 'Southern Cross' Expedition brought home from Cape Adare specimens of granites, basalts, and quartz slates, but unfortunately the latter proved to be unfossiliferous.

II. This section deals with the *volcanic islands* off the coast, commencing with the Balleny Group, in latitude 66° S., and passes on to the rocks of the mainland in latitude 77° S. The rocks from the islands are chiefly basalts and tuffs, though intrusions of trachyte are fairly common. Edward VII. Land and the volcanoes on the mainland are included in this section, as the latter, at any rate, belong to the recent volcanic eruptions of the area. All the volcanoes are undenuded cones, and are usually situated in isolated positions, and contrast strongly in outline with the rugged scenery of the main mountain range.

III. *The Continental Range.*—The great range of mountains discovered by Sir James Ross has been proved to be at least 800 miles long, and to have some remarkable features common to the whole length. This great mountain range is divided into smaller ranges, to which distinguishing names have been given; but only one, the Royal Society Range, has been examined in detail by the expedition.

The rocks that compose the range are conveniently separated into four distinct groups—namely, gneisses, granites, sandstones, and dolerites. The sandstone, to which it is proposed to give the name Beacon Sandstone Formation, provides a convenient stratigraphical datum line, with reference to which the other phenomena may be considered.

(i.) *The gneissic rocks* occur at sea-level and below a sequence of rocks which is at least 12,000 feet thick, and may be safely regarded as forming the ancient platform on which the central part of South Victoria Land is built. The foot-hills of the Royal Society Range and the lower portions of the Cathedral Rocks are composed of this class of rock.

(ii.) *The granites* have been encountered at the north end of the Royal Society Range, where they rest upon gneisses, and dykes of granite pierce the gneissic series. At Granite Harbour this type of rock is found as a huge boss, and is probably covered by a sheet of dolerite. Where the Ferrar Glacier bifurcates, a junction of dolerite and granite proves that there are two distinct developments of granite, one older and one younger than a certain sheet of dolerite.

(iii.) *The Beacon Sandstone Formation* is met with at a height of 4,000 feet above sea-level, and about 40 miles from the sea. It appears to be nearly 3,000 feet thick, and near the top indeterminable fossil plants were found. The bedding is practically horizontal, and the rock is remarkably uniform in texture. The surface upon which it rests has not yet been discovered.

(iv.) *The dolerite sheets* produce the plateau-features characteristic of that rock, and cap the sandstone over a very large area. Dykes, sills, and pipes of the dolerite occur in the sandstone, and prove the former to be intrusive. The original dolerite plateaux have been dissected by water action, apparently prior to the faulting which has dislocated the Beacon Sandstone.

IV. *The Ice.*—Sea ice, produced by the freezing of the sea during the winter, is on an average $8\frac{1}{2}$ feet thick, but during the summer the sea-water melts the lower surface of the ice. Shore-ice, a fringe of glacier ice attached to the land, shows the conservative action of ice in this latitude. Inland ice, local ice-caps, piedmonts, and other types of glaciers may be recognised in South Victoria Land. The term '*floating-piedmont*' has been suggested as descriptive of the Great Ice Barrier, or Ice Sheet, of Ross, and there are at least three examples in our area.

The moraines high on the slopes of Mount Erebus, and other moraines stranded at various spots, are considered in their relation to the past and present distribution of the ice, and the conclusion arrived at is that the glaciation is approaching a minimum.

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5. *Baviaan's Kloof: a Contribution to the Theory of Mountain Folds.* *By* Ernest H. L. Schwarz, *A.R.C.S.*

Baviaan's Kloof is a narrow valley lying between mountains formed during the Triassic period. The subsequent geological history may be summarised thus:—

(*a*) First base level. Deposition of the Enon Conglomerate, derived from the disintegration of the newly formed mountains, on a plain or flat double-bevel eroded between the two mountain chains.

(*b*) Period of cross-folding. The area was traversed by two sets of folds in directions W.N.W.–E.S.E. and S.W.–N.E., which let down portions of the surface in deep pits, bounded by circular faults and sharp folds.

(*c*) Second base level. The Enon Conglomerate was removed, except that in the fold-basins, and the surface of the valley again reduced to a double bevel of erosion.

(*d*) Rising of the land. Deep erosion of the river channels; immense gorges cut in the floor of the plain and most of the loose Enon Conglomerate remaining in the fold-basins removed.

Cross-folding is the interpretation of the two sets of mountain folds, and the sinking of areas in the meshes between them is contrary to what would happen if

the folds were produced by direct tangential thrust. The direct thrust theory also has to explain how a force could act at a distance when the material through which it is transmitted is so heavy in proportion to its strength, and there is therefore immense friction to overcome.

The resemblance of these Baviaan's Kloof fold-basins to pits found between two sets of crossing ripple marks has suggested that certain mountain folds are produced by earth-shaking waves which become retarded when approaching an immovable buffer, such as a mass of granite anchored to the deep sub-structure of the earth's crust. This theory is further illustrated experimentally by what happens in a lead sink where hot and cold water are let in alternately at one end from a tap; the disturbances produced by this gradually cause ridges to form at the further end of the sink, though the lead is too pliant to allow a direct thrust thus to act at a distance.[1]

'Schaarung' and 'fold arc' structure may also be explained on the wave theory, whereas 'block up-lift' structure is rather a problem in isostasy.

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6. *Report on the Fossiliferous Deposits at Kirmington, Lincolnshire.*

See Reports, p. 160.

JOHANNESBURG.

TUESDAY, AUGUST 29.

After the President had delivered his Address (see p. 375) the following Papers were read:—

1. *The Rhodesian Banket. By* Professor J. W. Gregory, *F.R.S.*

The first extensive contribution to the geology of Rhodesia is in Sawyer's 'Goldfields of Mashonaland,' wherein he called attention to the existence of some very ancient conglomerates. These beds have recently been the subject of lively controversy, as they have been proved to be locally auriferous, and as they have been called 'banket.' Protest was promptly made against their identification as banket on the grounds, (1) that banket is a local term which should be restricted to the Rand or at least to the Transvaal; (2) that the beds are not true sedimentary conglomerates, but are either crush-conglomerates (as advocated by Griffiths) or eruptive breccias (as maintained by von Dessauer). The author has recently examined the beds in the field, and found that several distinct things have been included in Rhodesia as banket; among these are some crush-conglomerates and crush-breccias, and a diorite dyke with amphibolite segregations; but the main mass of the material is a sedimentary conglomerate. The sedimentary origin of this latter material is proved by five lines of evidence: (1) the conglomerates alternate with fine quartzites which are uncrushed, and sometimes show well-preserved current-bedding; (2) the shape of the pebbles is that characteristic of typical sedimentary conglomerates, and not of crush-conglomerates or igneous breccias; the pebbles are not nipped or fractured, except where the conglomerate has been crushed, and such cases are met with in the Rand banket; (3) the pebbles include a very mixed assortment of rocks: granites, diorites, granulites, quartzites, vein quartz, cherts, jasperoid, schists, &c.; these rocks often resemble those found near the banket, but they do not necessarily consist of the immediately adjacent country rock; (4) pebbles of different rocks have different shapes and sizes, suggesting that they have travelled from different distances; thus at the Hunyani drift the quartzites commonly occur in flat slabs, the diorites in large irregular boulders, the granites or grano-diorites in round spherical balls; (5) their distribution is, as maintained by Mennell, inconsistent with their formation as crush-

[1] See Mellard Reade, *Evolution of Earth-Structure.*

conglomerates, and there is no field-evidence in favour of their origin as eruptive breccias.

The conglomerates, however, are not all sedimentary in origin; some of those included as banket are crushed quartz-lode, and to this category belongs the rock which most resembles the Rand banket in general aspect.

The conglomerates were examined by the author at various localities on both flanks of the old rocks that form the foundation of the present high veldt of Rhodesia.

The Rhodesian 'banket' differs from that of the Rand in several important characters. The Rhodesian 'banket' is fluviatile instead of littoral in origin; the size of the pebbles is often much larger and less regular; the pebbles vary more in composition, and the matrix is often a true schist. Moreover the author saw no adequate reason for correlating this conglomerate with the Rand banket, and regards it as older in age.

These differences would render it easy to draw up a definition of 'banket' that would exclude the Rhodesian conglomerates; but the author thought that in practice the term had been used—as by Molengraaff, Hatch, and Griffiths—for sedimentary auriferous conglomerates, and he therefore considered that Dr. Sauer was justified in applying the term 'banket' to the auriferous sedimentary conglomerates of Rhodesia.

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2. *The Indicators of the Ballarat Gold Fields: a Study in the Formation of Gold Pockets.* *By* Professor J. W. Gregory, *F.R.S.*

Complaint is often made against the Rhodesian gold fields on account of the patchiness of their gold. The Ballarat gold field is probably the patchiest of the leading gold fields of the world, and its history shows that such gold fields may be worked with economy and success after the discovery of the clue to the distribution of their gold pockets. The Ballarat gold field is in Victoria, about ninety miles west of Melbourne. It includes three lines of reefs, placed *en échelon*, a mile or two apart. The mines of Ballarat West are on big continuous quartz reefs in which the ore occurs in shoots. They presented no special difficulty; but the central and the eastern lines, viz., Ballarat East and Little Bendigo, presented no such main reefs. The slates and sandstones of these fields are seamed with a complex of quartz veins. The famous nuggets of Ballarat were found on the surface along a line running north and south through the Ballarat East field; but until the miners had a clue to the distribution of the gold pockets in the reefs efforts to work the mines below the alluvial deposits were not rewarded with much success.

It was at length noticed by Llewellyn that a gold pocket appeared to have been deposited at the point where a thin iron-stained line in the slates met a vein of quartz; he followed along this line, and found that where it intersected a quartz vein there was generally a rich pocket of ore. The quartz veins were barren, excepting where they met one of these iron-stained bands. Opposite them, for from six to eighteen inches, the quartz would be very rich. Elsewhere the quartz was barren. Llewellyn called these bands *indicators*, and they have been followed throughout the greater part of the Ballarat East gold field, the success of which has been largely due to their guidance.

These indicators were at first described as oxidised pyritic seams, and they have generally been regarded as sedimentary seams interstratified in the slates and quartzites of the country. This view has been widely expressed in mining literature. Bradford, on the contrary, maintained that they were not bands due to deposition, as he found that they crossed the bedding planes. The author has recently prepared a detailed account of the geology of the Ballarat gold field, including an account of the microscopic structure of the indicators. He finds that most of the indicators are seams of chlorite, and one of them is a narrow band of crowded rutile needles. Microscopic photographs, prepared by Mr. H. J. Grayson, were exhibited which conclusively proved the secondary origin of the indicators as they cross the bedding planes. They are in places composed of a

series of long, thin lenticles of chlorite arranged in lines traversing the slates. As the bands of slate are thin it is natural that the indicators should, as a rule, run parallel to the bedding; but in many cases, when examined in the mine or in sections under the microscope, the indicators are seen to cross the slates obliquely to the bedding.

3. *On the Relation between Ore Veins and Pegmatites.* *By* Professor R. Beck.

The author gave a summary of the latest investigations on the origin of pegmatites, by W. C. Brögger, H. Rosenbusch, S. Arrhenius, J. H. L. Vogt, U. Grubenmann, and others. In conformity with these authors, he explained pegmatites as products of crystallisation from the superheated water, which remained, after the consolidation of a plutonic magma, as a concentrated solution containing many of the rarer chemical elements and compounds formerly distributed through the whole fluid mass. Being retained in the depths of a plutonic focus under high pressure, these remains of magmatic water would pass through a very gradual process of cooling; whereas the so-called 'juvenile' thermal waters (*Juvenile Quellen*) of similar origin found their way to the upper parts of the earth's crust, and caused there the formation of minerals at lower temperatures and pressures.

Most ore veins belong to the second class, but a considerable number of occurrences may be styled metalliferous pegmatites.

The best known examples of these are found in the group of tin ores, and as such were discussed the ore veins of Zinnwald, Graupen, Embabaan, and others.

As examples of copper ores were cited those of Telemarken in Norway; and finally some gold-bearing quartz reefs were described which are very nearly related to pegmatites, and that not merely by their characteristic mineralogical composition (Berezowsk, Southern Appalachians, Yukon District, Passagem and other instances in Brazil). It may be mentioned in proof of this that certain gold quartzes contain tourmaline, the characteristic mineral of all pegmatites.

4. *Magmatic Segregation of Sulphide Ores.* *By* Dr. A. P. Coleman.

The formation of ore bodies by magmatic segregation in eruptive rocks has long been admitted as regards magnetite and titaniferous iron ores, but the formation of sulphide ore bodies in this way has been disputed by many geologists. The pyrrhotite ores of nickel in Norway were first recognised by Professor Vogt as having this origin; and his theory has been applied to the Sudbury nickel ores by various geologists, and opposed by others. The recent complete mapping of the eruptive sheet, with which the Sudbury ore bodies are all connected, proves that they are really segregated from the eruptive rock and form an integral part of it, with every gradation between ore and rock. It is believed that gravitation played a large part in the segregation, since the ore bodies are regularly found at the lowest points in the lower edge of the norite-micropegmatite sheet with which they are connected.

5. *On the Marginal Phenomena of Granite Domes.* *By* Professor Grenville A. J. Cole.

In examining the gneisses of the counties of Donegal and Tyrone, which have been in part regarded as sheared Archæan masses, the author was led to conclude that the main structures are due to igneous flow, and that the most marked gneissic structure occurs where previously foliated sedimentary and igneous material has been incorporated with an invading granite. The patches of foliated gneiss in the granites of Donegal are thus remnants of considerable masses of older rock that have been absorbed; and the phenomenon of banded gneiss arises characteristically as a marginal feature of granite domes. Foliation is found in surrounding masses parallel to that in the granite, and at the same time parallel

to the surface of junction, for the simple reason that the granite has picked off, leaf by leaf, the layers of foliated rock against which it rose. The author thus ranges himself with those who ascribe the most profound metamorphism to igneous rather than to dynamic action, and ventures to suggest that similar conclusions may be drawn from the rocks of the Malmesbury series in Cape Colony, where a commingling of rocks appears to have taken place during a period of subterranean flow. It is noteworthy that the relations of schist and granite at Seapoint, near Cape Town, were admirably described with characteristic insight by Charles Darwin in 1844. The composite character of banded gneisses was realised by Michel Lévy and by Callaway simultaneously in 1887.

WEDNESDAY, AUGUST 30.

The following Report and Papers were read :—

1. *Report on an Investigation of the Batoka Gorge and Adjacent Portions of the Zambesi Valley. By* G. W. LAMPLUGH, *F.R.S.*, *F.G.S.*—See Reports, p. 292.

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2. *Glacial Deposits of the Alps. By* Professor A. PENCK.

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3. *The Recent Work of the Transvaal Geological Survey.*
By HERBERT KYNASTON, *B.A.*

The present communication gives a general account of the principal results of the work of the Geological Survey of the Transvaal since the commencement of its present organisation. The author points out that the initial stages of the work were much facilitated by the previous and admirable labours of Dr. G. A. F. Molengraaff, late State Geologist, Dr. Hatch, and other Transvaal geologists.

The main divisions of the geological succession, as represented in the Transvaal, are considered in ascending order, and a short account is given of how our knowledge of each of these has been added to or modified by the work of the survey.

With regard to the older rocks, *i.e.*, those included within the South African Primary and Vaal River systems of Molengraaff, these have so far only just been touched upon by the survey, which has mainly confined its attention to the more central portions of the Transvaal, occupied by rocks belonging to the later systems.

The Transvaal system comprises the black reef series, the dolomite, and the Pretoria series, and is the Transvaal equivalent of the Campbell Rand and Griqua Town series of Griqualand West and the Prieska district.

The black reef series has been mapped between Pretoria and Johannesburg on the south, in the Lydenburg district on the east, and traversed in the Chunie mountains, south of Pietersburg, on the north. It rests immediately upon the old granite, or the up-tilted edges of the older sediments, with a very marked unconformity, and constitutes in the Lydenburg district the eastern edge of the High Veld Plateau, its most conspicuous feature culminating in the Devil's Kantor. The thickness south of Pretoria is insignificant, but the series attains a much greater development in the north, reaching a thickness of 1,600 feet in the Chunie mountains.

A considerable area of the dolomite and Pretoria series, which succeed the black reef with perfect conformity, has now been mapped, mostly by Mr. A. L. Hall, in the Pretoria and Lydenburg districts. Mr. Hall's detailed study of the

neighbourhood of Pretoria has thrown considerable light upon the structure of that area, and has shown how the strike of the Pretoria series and dolomite has been bent sharply to the south by the aid of a series of dislocations, sometimes nearly coinciding with the strike, and causing a repetition of the beds at the surface in a very striking manner.

With regard to the series of the Waterberg sandstones—probably the equivalent of the Matsap series of Stow in Griqualand West—the most important result of the work of the survey is the definite demonstration by Mr. E. T. Mellor of a decided unconformity between this series and the Pretoria beds, the evidence of which is very clear in the neighbourhood of Balmoral, east of Pretoria. It has further been shown that the red granite of the Bushveld is intrusive in and therefore of later date than the Waterberg sandstone. Mr. Mellor's more recent work to the north of the Eastern Railway line, on Rhenoster Kop, has shown that the deposition of the Waterberg sandstones was ushered in by manifestations of volcanic activity of very marked intensity, and that we must include in the lower portion of the series a considerable thickness of acid volcanic rocks, agglomerates, and conglomerates.

With regard to the red granite and its associated acid and basic rocks, which cover such large areas in that portion of the Central Transvaal known as the Bushveld, these rocks and their principal variations have been studied by Mr. Hall and the author, and much evidence has been collected showing the intimate connection, in point of origin, between the various types. These constitute a petrographical province of considerable magnitude, and one which has played an important rôle in the geological history of the Transvaal. The whole complex, varying as it does from the acid red granites of the Bushveld to the pyroxenites, serpentines, and magnetite rock, which occur associated with the marginal belt of norites, forms another and striking example of differentiation from a parent magma, resulting on the whole in increasing basicity from centre to margin, and may not unreasonably be regarded as constituting a gigantic laccolitic intrusion, or series of intrusions, between the Pretoria and Waterberg series. The work of Mr. Hall has further considerably added to our knowledge of the nature and mode of occurrence of the cassiterite deposits of the Bushveld.

Passing on to the Karroo system, a number of outliers of Karroo grits have been mapped to the north, north-east, and east of Pretoria, at the base of which beds of conglomerate, undoubtedly of glacial origin, frequently occur, corresponding in position to the well-known Dwyka conglomerate of Cape Colony. Associated with this deposit Mr. Mellor has recorded several excellent examples of glaciated land surfaces, considerably further north than any previously observed, and he has shown from the evidence of the glacial striæ, which are very clearly marked, and from the character of the boulders in the conglomerate, that the general direction of ice-movement was from north to south.

The pale fine-grained sandstones which border the Springbok flats have been shown by Mr. Mellor to be of Karroo age, and not to belong to the Waterberg series as previously supposed. These standstones overlie a series of grits seen near Pienaar's River, and are overlain by the extensive flows of basic lavas—the so-called Bushveld amygdaloid—which constitute the central portion of the Springbok flats. It is interesting to note that a similar succession was found bythe author in a recent survey of the Karroo rocks of the eastern low country, in the neighbourhood of Komati Poort.

The author concludes with a brief reference to the diamond pipes of the Pretoria district, with special reference to the included masses of Waterberg rocks in the Premier pipe, and the occurrence of hard blue ground, or 'hardibank,' in the Schuller pipe.

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4. *The Correlation between the pre-Karroo Beds of the Transvaal and those of the Cape Colony.* *By* Dr. F. H. Hatch.

The correlation of the pre-Karroo rocks of South Africa is a fascinating problem that has engaged the attention of most South African geologists at one

time or another, but the various conjectures hitherto put forward have not stood the test of time. The best-known attempts to connect the Transvaal with the Cape formations are those of Schenck[1] and Molengraaff.[2] The suggestion of the former was that the lowest Witwatersrand beds represented the base of the Table Mountain sandstone, while Dr. Molengraaff thought that the threefold sequence of the black reef, dolomite, and Pretoria beds corresponded with the three conformable members of the Cape system, thus:

3. Pretoria Beds	=	Witteberg Series.
2. Dolomite Series	=	Bokkeveld Series.
1. Black Reef Series	=	Table Mountain Series.

The fact, however, that at the Cape the basement beds of the Karroo system (viz., the Dwyka series) succeed the Witteberg series conformably, while in the Transvaal the Dwyka conglomerate lies unconformably on the Waterberg sandstone, which itself rests unconformably on the Pretoria series, shows clearly that neither of these correlations can be maintained.

The author of the present communication and Dr. Corstorphine in their recently published 'Geology of South Africa'[3] give reasons for correlating the base of the Waterberg sandstone with that of the Table Mountain sandstone. The clue to this view was first afforded by the Cango series of the Oudtshoorn district in the Cape Colony, which has been shown by the Cape Survey to be older than the Table Mountain sandstone. The Cango series contains a dolomitic limestone comparable in all respects with the well-known dolomite of the Transvaal, and it is overlaid by dark slates resembling those of the Pretoria series, and underlaid by beds of a quartz-felspar-grit, not unlike the arkose quartzite so often found at the base of the black reef series. It seems therefore more than probable that the Cango dolomite is of the same age as the Transvaal rock; and if this assumption be true the lowest member of the Cape system (viz., the Table Mountain sandstone) can only be represented by the Waterberg sandstone, while the two upper fossiliferous members (viz., the Bokkeveld and the Witteberg series) are wanting in the Transvaal.

The Ventersdorp system of the Transvaal, which is continuous into the Northern Cape Colony, where it appears as the amygdaloids of the Vaal River, and as the melaphyres, quartzites, and quartz porphyries found below the Ecca beds in the shafts of the Kimberley diamond mines, is probably represented in the Southern Cape Colony by the Cango Conglomerate and the Ibiquas series (in part), while the Witwatersrand system is entirely absent at the Cape.

The scheme of correlation put forward by the author and Dr. Corstorphine is then as follows:—

	Southern Cape Colony	*Northern Cape Colony*	*Transvaal*
	Base of the Karroo System	Base of the Karroo System	Base of the Karroo System
Cape System	Witteberg Series	(missing)	(missing)
	Bokkeveld Series	(missing)	(missing)
	Table Mountain Series	Matsap Series	Waterberg Sandstone

[1] A. Schenck, *Die geologische Entwickelung Südafrikas.* Petermann's *Mittheilungen*, Band 34, 1888, pp. 225–232.

[2] G. A. F. Molengraaff, Report of the State Geologist of the S.A. Republic for the year 1897, *Trans. Geol. Soc. S.A.*, vol. iv. p. 119. Johannesburg, 1898.

[3] *The Geology of South Africa*, by F. H. Hatch and G. S. Corstorphine. Macmillan and Co., London, 1905.

	Southern Cape Colony	*Northern Cape Colony*	*Transvaal*
Cango Beds	Slates Dolomitic Limestone Grits	Griquatown System: Griquatown Series Campbell Rand Series Keis Series	Potchefstroom System: Pretoria Series Dolomite Series Black Reef Series
	〰〰〰	〰〰〰	〰〰〰
	Cango Conglomerate and Ibiquas Series (in part)	Amygdaloids of the Vaal River	Ventersdorp System
	〰〰〰	〰〰〰	〰〰〰
	(missing)	(missing)	Witwatersrand System
			〰〰〰
	Malmesbury Series and Granite	Namaqualand Series and Granite	Swaziland Series and Granite

N.B.—The wavy line 〰〰〰 indicates the presence of an unconformity.

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5. *An Instrument for Surveying Deep Boreholes.* *By* Dr. F. H. Hatch.

The author described Mr. Oehmen's instrument for surveying deep boreholes, and Mr. Payne Gallwey gave an illustration of the use of the instrument. By this ingenious instrument the deviation from the vertical and the direction of the deviation are recorded by taking photographs of the position of a plumb-bob and a magnetic needle at any desired point in the borehole. The photographs are taken by means of two small incandescent lamps, which are illuminated by a dry battery after the instrument has been lowered to the desired point by means of a time-contact regulated by a watch. The amount of deviation and its direction are calculated from the photograph after the sensitised paper has been developed at the surface, and check results are found to be most consistent. The amount of deviation is calculated by measuring the distance between the centre of the photograph of the plumb-bob and the centre of the disc, the length of the plumb-bob being a known factor. The direction of deviation is obtained from the photograph of the magnetic needle, the correct orientation being fixed by two pin-pricks, which have the same relative position both on the photograph of the needle and on that of the plumb-bob.

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6. *On the Geology of Basutoland.* *By* Rev. S. S. Dornan.

The rocks of Basutoland belong to the Stormberg series of the Karroo system and consist of—

4. Volcanic beds	600 to 4,000 feet.
3. Cave sandstone	150 to 300 feet.
2. Red beds	300 to 500 feet.
1. Molteno beds	600 +, (exposed base not seen).

together with surface and recent accumulations.

The Molteno beds comprise sandstones, shales, and mudstones, grey and greenish in colour, loose in texture, and presenting a glittering appearance upon fresh fracture. Nodules also are of frequent occurrence.

Plants have been found in the Matabele district of Griqualand East, and a few, so far, in Basutoland. The Molteno beds contain thin seams of coal. Several are known to exist in Basutoland, but are not worked (except in one instance) by the natives, who are afraid of the white man, as they say that if they allowed the whites to prospect for minerals they would lose their country. Conglomerates

also occur. One above the coal seams has a large amount of ferruginous matter. Fossils are not plentiful. A portion of a reptilian humerus has been obtained from the conglomerates.

The Red beds lie conformably on the Molteno beds, being distinguished principally by their prevailing colour. It is extremely difficult to make any definite separation from the beds below. They consist of Red sandstones, blue, green, and chocolate-coloured mudstones and shales. Ripple marks and false bedding occur. No fossils have been found except a few specimens of silicified wood. The average thickness is about 300 feet, but in many places much more. They are thicker in the north of Basutoland and the Orange River Colony. The Cave Sandstone beds are extremely difficult to separate from the Red beds, as they pass into each other gradually. The cave sandstone forms the crests of the hills. Its bedding planes are not well developed, and individual beds rather thick. It weathers into huge pillars, which in falling down strew the slopes with large blocks. It contains caves formerly used by Bushmen, and later by cannibals. These caves sometimes contain Bushmen paintings, *e.g.*, that at Qalo. A large cave near Cana is still called the Cannibals' Cave by the natives, from the red colour of a sandstone ledge, where the cannibals are said to have slaughtered their victims.

Fossils are comparatively rare, but reptile tracks are fairly abundant. At Qalo two impressions can be seen on a fallen slab, the middle toe of which is 13½ inches long. At Morija there are two slabs, the smaller of which contains one large and a few small impressions. The larger contains three sets of impressions, evidently belonging to different individuals. Those of the largest set are 12 inches long, with a stride of from 2 feet 7 inches to 3 feet. Fish have been found at Ficksburg and Masitise, but it is uncertain whether they came from cave sandstone. A skull described in Zittels' 'Palæontology' is said to have come from Thaba Chou, Basutoland, but the locality cannot be identified.

The volcanic beds occupy the higher ridges of the Malotis and Drakensberg ranges, with a few outliers such as Thaba Isuen, &c. Their total thickness must be 4,000 feet. There seem to have been two phases of volcanic activity, yielding, respectively, the lava beds and the intrusive sheets. The latter do not penetrate to the Red beds, while the former occupy the tops of the hills. Basaltic dykes, in connection with the intrusive sheets, traverse the lava beds. On Thaba Isuen an interesting section can be seen. The mountain consists of three terraces, each with certain characteristics. The lavas are doleritic near their junction with the Cave Sandstone, higher up they are amygdaloidal upon what was probably the old crater-wall, while the plug consists of dolerite and agglomerate. East of Morija are two other examples of volcanic plugs, with characteristics similar to Thaba Isuen. They are also found in the north-east of the Orange River Colony at Fouriesberg.

The intrusive sheets, or at least some of them, seem to be later, as the dykes in connection with them traverse the volcanic beds, and run for miles across the country.

The Cave Sandstone and Red beds lie horizontally upon some sheets, which would show that they are more recent than the lava-flows.

Recent and superficial deposits occupy the plains, and comprise stratified clays, sands and gravels, through which the present rivers have cut their channels. The drainage of the country seems to have followed pretty much its present lines, the Caledon and other rivers having cut deep channels, which indicates that their courses have not undergone alteration for a long time.

The most interesting of these recent deposits is the blown sand on Thaba Bosin, occupying a space of many acres. The sand travels gradually east or west, owing to the direction of the prevailing winds, but does not fall over the precipice owing to the updraught of the wind rushing round the hill.

A few fossils have been found in these beds belonging to existing species, some of which, as the hippopotamus and warthog, no longer exist in the country.

This paper is only a sketch of a small part of the country, and therefore is in no sense complete.

FRIDAY, SEPTEMBER 1.

The following Papers were read:—

1. *The Dolomite Formation of the Transvaal. By* C. BARING HORWOOD.

The dolomite forms a considerable area of undulating grass country in various parts of the Transvaal, and is important as being practically the only source of the permanent rivers of the country. It lies conformably between the Black Reef Series and the Pretoria Series, forming with them the Potchefstroom System. This, however, is bounded above and below by unconformities, so that, as fossils are wanting, its age is not known.

The dolomite is probably a deep-sea deposit, which has subsequently been dolomitised in shallow water, and has lost in the process all traces of stratification and organic remains. The upper layers contain much chert.

In the East Rand it is associated with uniform layers of syenite or tonalite, which may probably be connected in origin with the plutonic series of the Bushveld.

Gold occurs at Malmani in quartz fissure-veins, and in narrow interbedded quartz sheets in the Lydenburg district.

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2. *On the Discovery of Marine Fossiliferous Rocks of Tertiary Age in Natal and Zululand. By* WILLIAM ANDERSON, *F.R.S.E.*

Tertiary rocks of marine origin have not previously been recorded from South Africa. The present occurrences are confined to the coast of Natal and Zululand. The nearest outcrops of marine tertiaries are on the west coast of Madagascar. In Zululand they rest upon rocks which are known to be of Upper Cretaceous age and form a series of considerable thickness. They consist of highly coloured sand, showing false bedding, marls, and shales. In the upper portion of the shales and marls marine mollusca with foraminifera are plentiful, but not particularly well preserved, although sufficiently so for identification. The mollusca were identified by Mr. R. Etheridge as of probably Eocene age, while the foraminifera were stated by Mr. Hinde to be of Tertiary age. In the lowermost beds, exposed at low water, large quantities of mammalian bones occur in the shales. In most cases the individual bones are isolated specimens, although large portions of the vertebral column and the complete pelvic girdle of a large mammal were found in one piece. Associated with these remains are numerous large water-worn fragments of fossil wood, fish, and crustacean remains. The evidence points to the estuarine origin of the lower mammalian shales. Among the more common genera which occur are the elephant, rhinoceros, hippopotamus, with many others which have still to be identified.

The other locality in which rocks of probably Tertiary age occur is on the Bluff, near Durban. This headland consists of a coarse, calcareous grit, with marine fossils which, so far, have not proved sufficiently well preserved for identification. It is more than probable, however, that the sandstones of the Bluff will prove to be of Tertiary age. In a bore recently put down on the Bluff for coal, over 300 feet of this calcareous sandstone was passed through, followed by over 300 feet of undoubted Upper Cretaceous rocks, which rest unconformably on the Ecca shales of the district.

This discovery of mammalian remains in marine Tertiary beds appears to be of considerable importance to South African geology, especially when considered in connection with the discovery of the remarkable series of extinct animals which have lately been obtained from the deposits of the Fayûm desert by the officers of the Geological Survey of Egypt.

Geol. Mag. 1896. p. 487. pl. 15

3. *Evidences of Glacial Conditions in Permo-Carboniferous Times in the Transvaal.* By EDWARD T. MELLOR, *B.Sc.*

(Communicated by permission of the Director of the Geological Survey of the Transvaal.)

The present paper gives a brief account of recent work in connection with the rocks at the base of the Karroo System in the Transvaal, including some additions to the evidence of extensive glacial action in early Karroo times. The description given of the character and mode of occurrence of the glacial conglomerate is based mainly upon observations made in the course of mapping a district lying between the Elands and Wilge Rivers, east of Pretoria. The Karroo System does not here attain so complete a development as in the more eastern and southern portions of South Africa. The whole thickness of the formation rarely exceeds 400–500 feet, and it is not possible as yet to recognise the many divisions which it presents in those parts of South Africa where it attains a much greater thickness. Outliers along the margin of the main area occupied by the Karroo System afford good opportunities for the study of the glacial conglomerate which forms its base. They are occasionally entirely composed of this conglomerate owing to the complete denudation of the overlying sandstones and grits.

The upper and well stratified portion of the formation lies everywhere horizontally, and its base maintains a very constant elevation of about 4,900 to 5,000 feet. The glacial beds of the lower portion of the formation rarely show distinct stratification, and outliers consisting of these alone closely resemble, both in appearance and mode of distribution, patches of glacial drift of comparatively recent origin. There is abundant evidence that they were laid down upon an old land surface possessing considerable variety of surface feature, and some of the thickest deposits of glacial conglomerate occur in valleys or below escarpments which were in existence before its deposition.

Owing to the abundant sandy drift arising both from the conglomerate itself and from the grits and sandstones which usually overlie it, the solid conglomerate is rarely exposed at the surface. Where seen, it is of a light yellow or cream colour, and usually consists of a sandy-looking matrix containing abundant boulders and pebbles distributed without definite arrangement through the mass. The pebbles and boulders vary in size from 2 to 3 inches up to as much as 10 feet in diameter. The materials of which the boulders are composed vary much in character. There is always a great preponderance of local rocks with an admixture of others which can be shown to be derived from comparatively distant sources, which are to the north of the present position of the boulders. In the district here specially referred to, the majority of the boulders consist of hard red quartzites and conglomerates derived from the Waterberg Formation which underlies the glacial conglomerate over a large part of the area. Almost equally numerous are boulders of the Red Granite which occurs extensively further to the north.

The boulders are always highly polished and usually facetted. When composed of fine-grained rocks, such as felsites and shales, they frequently show striations on the facets. The matrix of the glacial conglomerate consists of sharply angular fragments of quartz and of rocks similar to those of which the boulders are composed, varying in size from mere grains upwards. It differs to some extent from the matrix of the typical Dwyka conglomerate of the more southern portions of South Africa in presenting an appearance much less suggestive of an igneous origin. On weathering, the matrix of the conglomerate usually gives rise to sandy products; in some localities, however, it produces a yellowish clay, in which the boulders remain embedded. In specimens from a depth, the matrix is occasionally greenish in colour. Locally there occur in the conglomerate lenticular patches of fine-grained, massive, white or cream-coloured sandstones, and white, finely laminated shales and mudstones.

The progressive denudation of the glacial conglomerate exposes at its margin the glaciated surfaces of the underlying rocks, which frequently show very clear

striation. The best examples yet met with are those occurring to the north of the Douglas Colliery near Balmoral. In a number of examples distributed over an area of 300 square miles the striæ exhibit great constancy of direction, and point to the existence of an extensive ice-sheet with a movement from N.N.W. to S.S.E.

It is very probable that the glacial conglomerate extends very much further north than the localities at present known. During the past year outliers of the conglomerate were found ninety miles north of the latitude of Johannesburg.

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4. *Note on the Occurrence of Dwyka Conglomerate at Kimberley Mine. By* G. W. LAMPLUGH, *F.R.S.*

The author described the occurrence of glaciated boulders in the Dwyka conglomerate and the cast of a glaciated surface, with striæ running E. 30° N. in the open shaft of Kimberley mine.

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5. *The Diamond Pipes and Fissures of South Africa. By* HAROLD S. HARGER.

The author leads up to the subject of the formation of the diamond pipes and fissures by pointing out that for vast ages a great portion of South Africa was under water, during which period 14,000 feet of sediments were laid down, forming the great Karroo system of fluviatile and lacustrine rocks. Their deposition was accompanied by a gradual subsidence or depression of the whole formation, during which faulting and fracturing of the earth's crust occurred, assisting the infiltration of overlying waters and the generation of steam, and ultimately influencing widespread intrusions of basic, igneous rocks, such as dolorite and basalt. The whole series was afterwards raised again to its present level. At the close of the great period of immersion and deposition of sediments, violent quakes and explosions occurred, shattering the earth's crust and facilitating the formation of volcanic rocks and huge fissures out of which issued enormous outpourings of amygdaloidal lavas, over 4,000 feet in thickness along the Drakensberg range. Following this period of activity came the intrusion of numerous volcanic pipes and fissures filled with the diamond-bearing 'blue ground' termed by Professor Carvill Lewis 'Kimberlite.' This blue ground is a serpentine-breccia, and contains a larger number of minerals than any other known rock. The most prominent of these minerals are garnet, ilmenite, various pyroxenes, olivine, and mica, all of which are derived from the shattering to pieces of deep-seated ultra-basic and other rocks dissected by the pipe during the upward passage of the Kimberlite. The age of the pipes in the Cape Colony and O.R.C. is considered by the author to be late Triassic or Jurassic, and the Pretoria pipes, for stated reasons, are contemporaneous. They are the latest eruptives of South Africa. The presence of many pipes on lines of weakness indicated by fissures filled with Kimberlite suggests that most of the pipes originated on fissures, and are therefore closely associated with the latter. Both contain the same minerals and also diamonds, and their origin was due to the expansive force of great quantities of imprisoned vapour generated at vast depths and liberated with sudden violence.

The origin of the blue ground in the pipes he considered due to the shattering of the ultra-basic rocks such as eclogites, pyroxenites, and lherzolites, all of which are commonly met with, and are made up of the minerals which form the bulk of the blue ground. In these rocks garnet occurs plentifully, and also olivine and pyroxenes. The diamond has frequently been found crystallised in garnet, and more rarely in olivine; hence the precious gem must have had its genesis in the ultra-basis zone in which those minerals originated. The experiments of Sir William Crookes and of Moissan suggested that the presence of iron was necessary for the formation of the diamond, but to this the author objects owing to the fact that the necessary iron does not exist in the diamond mines, and because Dr. Friedländer's experiments prove that diamond can be formed in

olivine without the enormous pressure and heat used by other experimenters. He concludes with the opinion that a very deep-seated ultra-basic zone in which garnet and ferro-magnesian silicates predominate saw the crystallisation of diamond.

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6. *On the Geology of the West Rand.* *By* Dr. J. T. Carrick.

The results of a survey of the West Rand, made by the author in 1899, agree in the main with Dr. Hatch's geological map of the Southern Transvaal published in 1897. In the author's opinion it is not yet certain that the granite to the north of Johannesburg is all of one age. The schists belong to the horizons respectively older and younger than the base of the Witwatersrand system. The author considers that the Botha's and Main Reef series are identical.

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7. *The Plutonic Rocks and their Relations with the Crystalline Schists and other Formations.* *By* F. P. Mennell.

In this paper the term 'plutonic' is restricted to those vast and structurally uniform masses of igneous material whose superficial extent is matched by their extension in depth. No mere coarsely crystalline dyke comes under this head, and it may even be doubted whether any rock but granite strictly fulfils the above conditions. Such rocks will have consolidated not so much from intrusion into the cool upper zones of the earth's crust, but because the liquid condition is a state of unstable equilibrium at the normal depth-temperature, and cannot survive the cessation or reversal of such crust movements as have temporarily given rise to fusion. Despite these restrictions plutonic rocks are extremely common in South Africa, nearly all being of later date than our uppermost Archæan rocks, but older than the lowest of the later sediments. The geologist is able to examine the very roots of the great mountain chains, of which the granites must once have formed a core, probably at the beginning of the Palæozoic period.

Petrological Problems.—(i) *Composition.*—It quickly becomes obvious that granite, instead of being an extreme of the igneous series, represents almost exactly the average composition of the igneous rocks (see 'Geol. Mag.,' June 1904, p. 263). The conclusions drawn from actual observation in such an area as Rhodesia, chiefly occupied by igneous rocks, do not at all tally with inferences based merely on laboratory work, which do not allow for bulk—really the essential feature of the problem.

(ii) *Causes of Heterogeneity.*—But though we find that granite, which is practically uniform over enormous areas (often many thousand square miles, in South Africa), is by far the most important igneous product, we have still to account for the fact that other rocks are met with which differ widely both among themselves and from the granitic average. Appearances point to some genetic relation between even very divergent types, and it has been suggested that all have been derived from a single homogeneous magma. But the existence of such a magma, even in a single province, seems unaccountable, and granting its possibility we do not find the suggested causes of segregation to be satisfactory. They are without exception either contrary to physical principles or quite incapable of producing the effects ascribed to them, except on a small scale.

We are accordingly forced to consider whether there may not be other explanations of the facts. And indeed we constantly find, even in the case of limited exposures of the upper zones of plutonic masses, evidences of the derivation of material from the surrounding rocks (chiefly crystalline schists). But it is no use appealing merely to a certain amount of absorption as the cause of rock-variation. We must go back to the origin of the magmas themselves. It seems certain that the plutonic masses, as we know them, must result from the melting down of other pre-existing rocks, whether igneous, sedimentary, or metamorphic. They have certainly been liquid at one time or another since the earth reached its present stage of cooling, so that, unless we reject the solid-earth theory, they must have

been produced by the refusion of once solid material. The evidence only points to granite resulting from the effective mixing of heterogeneous materials rather than to its being a mere residuum left after the abstraction from a magma of its basic material.

(iii) *Original Constitution of the Magmas.*—There is nothing to show that the earth was ever homogeneous in composition, or even composed of anything approaching homogeneous layers. We must consequently accept even the oldest plutonic rocks as the result of the fusing of very diverse materials, the diversity increasing as more and more sediment came under the influence of refusion, from limestones with little or no silica to sandstones with up to 100 per cent. By the intimate mixture of all classes granite is evidently produced; but where the mixing is dependent to any considerable extent on diffusion heterogeneity would prevail for long periods of even geological time, and segregation might even locally increase it. All the usual features of a petrographical province, including the predominance of basic lavas but of acid plutonic rocks, are readily deducible from such conditions.

(iv) *Circulation of Material.*—On the above basis it will be seen that there must be circulation of material between the igneous and sedimentary rocks Starting on the first-formed rocks of the cooling earth, the agencies of denudation have been constantly at work sorting the materials subjected to their action. Free silica, unaltered from its original form as quartz, has been separated from its associated minerals and formed into sandstones; felspar, altered indeed but not out of all recognition, has given rise to clays and shales; while the ferro-magnesian minerals, far more profoundly changed, have provided the material for limestones and dolomites, as well as colouring and cementing matter for rocks of all classes.

Sedimentation indeed constitutes a very real analysis of the rocks on which it has to work. The accretion of the plutonic igneous masses, as we now know them, is precisely the reverse. In its course the varied materials which have been so laboriously sorted out by mechanical and chemical agencies are melted down, as it were, in one vast crucible. They are subjected to a very effective process of synthesis, and eventually cool down to become once more available for fresh sorting operations when a new cycle begins in its turn.

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8. *A Consideration of the Archæan Period of the Continents of North America and South Africa, with reference to Mineral Occurrences. By* E. F. HENEAGE.

The study of Archæan rocks, though it may lack the peculiar interest attaching to that of fossiliferous strata, and is beset with more difficulties in respect of the decipherment of their history, is nevertheless one of much interest and of very great importance, for in the right reading of their history lies a key to the secret of the formation of the deposits of mineral wealth.

The author considers first the continent of North America, and the connection of its Archæan rocks with its mineral wealth. Using the word 'Archæan' (so far as regards America) as including Logan's Laurentian and Huronian systems, the Archæan rocks cover an area of about 2,000,000 square miles in Canada and Labrador, and large areas from Newfoundland to Georgia. They form the basis of the chief mountain ranges, and occur in many isolated parts of the continents. The Huronian rocks are characterised by vast beds of iron ore, of which the most noted are those of the Marquette district of Lake Superior, where the hæmatite is closely associated with jasper and intermingled with quartzite, chert, gneiss, and diorite, as it is also in the Menominee district and in the Vermilion Lake district. The origin of these deposits has been a matter of great controversy. In New York are extensive beds of magnetite ore, as well as in the Adirondack region and in Virginia and North Carolina.

Titaniferous magnetite ore, occurring in labradorite rocks in Canada and the Adirondacks, is also of much scientific interest, and seems to favour the hypothesis

that these ores in Archæan rocks have their origin from the molten magma beneath.

Other ores found in the Archæan rocks are galena, copper, gold and silver, tin, nickel, platinum, and aluminium.

Turning to South Africa, we find a similar basal complex of granites, gneisses, and schists, showing some evidences of having been subjected to great dynamic forces, throughout British Bechuanaland, the Transvaal, Rhodesia, and Natal.

Crystalline and metamorphic schists occurring in patches or as bands in the granite constitute the chief source of mineral deposits. In Rhodesia the field extends over about 42,000 square miles. Messrs. Chalmers and Hatch, in a paper in 1895, dealt with this region, and came to the conclusion that the auriferous schists were formed from dolerite intrusions through fissures formed by the folding of the granitic crust. The author's observations lead him to the same conclusion as regards some of the auriferous schists in the Transvaal, and a number of slides cut from these schists bear evidence to the correctness of this opinion.

The author concludes that there exists in South Africa a far higher development of Archæan rocks than is probably to be found elsewhere, which provide an immense field for most interesting research, though, unfortunately, over large areas the ancient series are so covered with younger formations of sandstone as to make a thorough investigation of them impossible.

Section D.—ZOOLOGY.

President of the Section—G. A. Boulenger, F.R.S.

CAPE TOWN.

WEDNESDAY, AUGUST 16.

The President delivered the following Address:—

The Distribution of African Fresh-water Fishes.

I think I may ascribe the honour of having been chosen to preside over this Section to the fact that I have specially applied myself to the study of a large class of the animals of the part of the world in which we are for the first time assembled. The subject of the Address which it is the custom to deliver on such an occasion was therefore not difficult to choose—a general survey of the African fresh-water fishes from the point of view of their distribution.

It has repeatedly been pointed out that no division of the world can answer for all groups of animals, differences due to the period at which they appeared and to their ability or inability to spread over obstacles, whether of land or water, precluding any attempt to make their present distribution fit into the frames of the general zoo-geographer. The great divisions of the earth, as outlined by our eminent Vice-President, Dr. Sclater, nearly half a century ago, and based mainly on a study of passerine birds, have therefore varied considerably according to the standpoint of the many workers who have followed in his footsteps. Fresh-water bony fishes particularly lend themselves to a uniform treatment, their principal groups having sprung up, so far as palæontological data teach us, about the same period in the history of the earth, and branched off in many directions within a, geologically speaking, brief lapse of time, most of them, besides, being regulated in their distribution by the water-systems. How greatly their distribution differs from that of terrestrial animals has long ago been emphasised. Thus, latitudinal range, so striking in many African reptiles, does not exist in fishes: the key to their mode of dispersal is, with few exceptions, to be found in the hydrography of the continent; and, as first shown by Dr. Sauvage, latitude and climate, excepting of course very great altitudes, are inconsiderable factors, the fish-fauna of a country deriving its character from the head waters of the river-system which flows through it. In this way, for instance, the Lower Nile is inhabited by fishes bearing a close resemblance to, or even specifically identical with, those of Tropical Africa, and strikingly contrasting in character with the land-fauna on its banks. Such being the case, it seems at first as if the geographical divisions of the fish-fauna were a matter

of extreme simplicity, and that a knowledge of the river-systems ought to suffice for tracing areas which shall express the state of things. But we must bear in mind the movements which have taken place on the surface of the earth, and owing to which the conditions we find at present may not have existed within comparatively recent times; and this is where the systematic study of the aquatic animals affords scope for conclusions having a direct bearing on the physical geography of the near past. To mention two examples, the fishes of the Nile show so many specific types in common with those of the Senegal-Niger, now more or less completely separated by the Chad basin, that we felt justified in postulating a recent communication between these water-systems, which has been fully confirmed by the study of the Lake Chad fishes; whilst, on the other hand, the greater difference between the fishes of the Nile and those of the Congo basin, the waters of which interlock at present in such a way that it is believed possible, at certain seasons, for a man in a boat to pass from the one into the other, points to the existence, until very recently, of a more effective separation. Such problems are of the greatest interest, and a more exact knowledge of the fishes will help towards their solution.

There is another aspect of the question of geographical distribution which has assumed special importance of late, especially in the writings of Professor Osborn, Mr. Lydekker, and Dr. Scharff, and of which Dr. A. E. Ortmann's paper on the distribution of Decapod Crustaceans, published three years ago, may be taken as an example. One of the conclusions formulated therein is that 'any division of the earth's surface into zoo-geographical regions which starts exclusively from the present distribution of animals without considering its origin must be unsatisfactory.' But in certain groups of animals, possibly in most, the question of their origin is not easily settled; in the case of the African fresh-water fishes, for instance, we sadly lack all direct palæontological data, such as have sprung up lately in marvellous profusion in the case of the mammals, and notwithstanding the great progress in our knowledge of the changes that have taken place in the configuration of the world in Secondary and Tertiary times, which has been conveyed to a wide circle of readers chiefly through the luminous works of Neumayr, Suess, and de Lapparent, there is still much that is open to discussion. It must be admitted—and it is well to draw special attention to this point—that Dr. Ortmann's maps of the land-areas in past periods, which render his suggestive paper so attractive, cannot be accepted as the expression of well-established geological facts, and are, in some respects, gravely misleading. If I have attempted to deal with this subject on the lines laid down by Dr. Ortmann, whilst realising the want of many necessary data, palæontological and geological, on which to base conclusions, it is with a due sense of humility, being fully aware that the suggestions now offered must be regarded as mere speculations.

The time has come for a stock-taking of our immensely increased material, the previous accounts of the distribution of African fishes given by Dambeck in 1879, by Günther and by Sauvage in 1880, and by Palacky in 1895, no longer answering, even approximately, to our present knowledge, as may be seen by comparing the lists given by these authors with the one I have quite recently published in the 'Annals and Magazine of Natural History' as a basis for the sketch here attempted.

How little we knew of the fresh-water fishes of Africa when the subject was dealt with by the above-named authors is exemplified by the enormous number of genera and species which have been discovered within the last few years, thanks chiefly to the enlightened activity of the Governments of Egypt and the Congo Free State, and to the initiative of Professor Ray Lankester in organising explorations of the great lakes of Central Africa. The waters of the French Congo and Cameroon, the Niger, Abyssinia, and the interior of East Africa, have also yielded a large number of novelties; even the Nile, comparatively so well known, has been productive of many and remarkable additions to our knowledge. The importance of a better acquaintance with the fishes of the Lower Nile, a district believed to have been particularly well explored, can be measured by

comparing the present data with those to which Professor Gregory, on the faith of Dr. Günther's list, appealed to justify his theory of a direct connection in the past of the Upper Nile with the Jordan through a river flowing along what is now the Red Sea. To this question we shall revert presently.

Whilst the exploration of rivers and lakes has resulted in such a rich harvest, it remains a matter for serious regret that we should still be without any information as to the precursors of the African fishes. In spite of diligent search over a considerable portion of the great continent, no remains of any post-Triassic fishes have yet been discovered in Tropical and South Africa, and our acquaintance with Tertiary Teleosts generally is still almost as scanty and fragmentary as it was twenty years ago, although much has been done by Dr. Smith Woodward in elucidating the affinities of such remains as have been exhumed. Under the circumstances we have to fall back on our imagination to explain the origin of the most important groups characteristic of the present African fish-fauna, and much hazardous speculation has been indulged in. Thus, without any sort of evidence, the Cichlid Perches of Africa have been supposed to emanate from ancestors inhabiting hypothetical Jurassic or Cretaceous seas extending over Central Africa, whilst connecting land areas have been too freely postulated to account for the resemblance between the fishes of Africa and Tropical America, and antarctic continents devised to explain the presence of *Galaxias* in South Africa. To these suggestions I shall refer further on when dealing with the distribution of the families to which they were intended to apply. Although it is highly desirable that zoologists should base their theories of geographical distribution upon geological data, I think we must regret the growing tendency to appeal to former extensions of land or sea without sufficient evidence, or even contrary to evidence, in order to explain away the riddles that offer themselves.

Twenty-five years ago a list of the African fresh-water fishes would have included the names of about 350 species (Günther gave the number as 255 only), some fifty of which have since lapsed into the synonymy, whilst at the present day we are acquainted with 976 species, referable to 185 genera and forty-three families. Of the latter five were then unknown, or unknown to have representatives in this part of the world. The forty-three families are here enumerated, with an indication of the number of genera and species according to the most recent census:—

CHONDROPTERYGII.

PLAGIOSTOMI.

1. Carchariidæ, 1, 1.
2. Pristidæ, 1, 1.

CROSSOPTERYGII.

CLADISTIA.

3. Polypteridæ, 2, 11.

DIPNEUSTI.

4. Lepidosirenidæ, 1, 3.

TELEOSTEI.

MALACOPTERYGII.

5. Elopidæ, 2, 3.
6. Mormyridæ, 11, 108.
7. Notopteridæ, 2, 2.
8. Osteoglossidæ, 1, 1.
9. Pantodontidæ, 1, 1.
10. Phractolæmidæ, 1, 1.
11. Clupeidæ, 6, 7.
12. Salmonidæ, 1, 1.
13. Cromeriidæ, 1, 1.

OSTARIOPHYSI.

14. Characinidæ, 20, 93.
15. Cyprinidæ, 12, 202.
16. Siluridæ, 37, 187.

APODES.

17. Anguillidæ, 1, 6.

HAPLOMI.

18. Galaxiidæ, 1, 2.
19. Kneriidæ, 1, 2.
20. Cyprinodontidæ, 5, 39.

CATOSTEOMI.

21. Gastrosteidæ, 1, 1.
22. Syngnathidæ, 2, 3.

PERCESOCES.

23. Scombresocidæ, 1, 1.
24. Atherinidæ, 2, 3.
25. Mugilidæ, 2, 13.
26. Polynemidæ, 3, 3,
27. Sphyrænidæ, 1, 1.
28. Ophiocephalidæ, 1, 3.
29. Anabantidæ, 1, 14.

ACANTHOPTERYGII.

30. Centrarchidæ, 1, 3.
31. Nandidæ, 1, 1.
32. Serranidæ, 6, 8.
33. Sciænidæ, 1, 1.
34. Pristipomatidæ, 2, 2.
35. Sparidæ, 1, 1.
36. Scorpididæ, 1, 3.
37. Osphromenidæ, 1, 1.
38. Cichlidæ, 30, 179.
39. Pleuronectidæ, 2, 2.
40. Gobiidæ, 2, 31.
41. Blenniidæ, 3, 3.

OPISTHOMI.

42. Mastacembelidæ, 1, 23.

PLECTOGNATHI.

43. Tetrodontidæ, 1, 4.

In discussing the distribution of the fresh-water fishes it is necessary to divide them into four principal categories:—

1. Those living part of the year in the sea. This category is again subdivided into anadromous forms, breeding in fresh water (ex. some *Clupea*), and catadromous forms, breeding in salt water (ex. *Anguilla*).
2. Those living normally in the sea, but of which certain colonies have become land-locked, or have separated themselves from the marine stock still represented on the neighbouring coast (ex. some *Gobiidæ* and *Blenniidæ*).
3. Those which, although entirely confined to fresh waters, have as nearest allies species living in the sea, and which there is reason to regard as more or less recently derived from marine forms (ex. *Galaxiidæ*, *Tetrodontidæ*).
4. Those belonging to families entirely (ex. *Mormyridæ*, *Characinidæ*) or chiefly (ex. *Siluridæ*, *Cyprinodontidæ*) restricted to fresh waters.

The forms of the first and second categories may be entirely neglected in dealing with the distribution of fresh-water fishes. Their range is regulated by the sea, and they must be dealt with in conjunction with littoral forms. Eighty-six species in the list of African fresh-water fishes belong to these categories.

The third category is of secondary interest in the history of the fresh-water fauna; but, as in the case of *Galaxias*, forms referred to it may give rise to discussion.

It is with the members of the fourth category that we shall mainly deal in the portion of this Address which is devoted to the origin and mode of dispersal of the African fishes.

THE POLYPTERIDÆ.—This is incontestably the most remarkable family of African fishes. Entirely restricted to Tropical Africa and the Nile, without any known near allies, living or extinct, its history is one of the greatest riddles in ichthyology. From the evolutionary point of view, no group is of greater interest, owing to its probable relation to the Chondropterygians or Elasmobranchs, to the Osteolepid Crossopterygians, out of which the Lung-fishes seem to have been evolved, and to the earliest pentadactyle vertebrates, the Stegocephalous Batrachians. Although generally brigaded by modern systematists with the Osteolepida in the order Crossopterygii, it is still doubtful whether it should not rank as a distinct order, Cladistia of Cope, the characters which differentiate it from these early Teleostomes being perhaps of greater importance than those which separate these from the Dipneusti. Perhaps the embryological material collected by the lamented J. S. Budgett, who sacrificed his life in his attempt to contribute to the solution of this great problem, will, when thoroughly worked out under the direction of Professor Graham Kerr, throw fresh light on the question. But it is rather to the future discoveries in the field of palæontology that we must turn our hopes. At present we know nothing on this subject, for I need hardly remark that Mr. Moore's assertion that *Polypterus* had allies in the Jurassic seas, and thus came to enter the lake which he regards as peopled with the remains of so ancient a fauna, is without any foundation, as is also his statement that Polypterid remains were discovered by Mr. Drummond on the north-west shore of Lake Nyassa, these fossils having been determined by Dr. Traquair as Palæoniscid and allied to if not identical with *Acrolepis*. We are at a loss to find an explanation for Mr. Moore's statement that these fossils, 'according to Professor Traquair, are similar

to, but specifically distinct from, the existing African species.' Until we have some proof of the contrary, we are justified in regarding the Polypteridæ as having arisen in Africa from fresh-water ancestors, themselves derived from early Mesozoic types which are entirely hypothetical.

THE LEPIDOSIRENIDÆ.—*Protopterus* in Africa and *Lepidosiren* in South America are specialised modifications of the *Ceratodontidæ*, still represented by one species in Australia, which have left remains in Triassic, Rhætic, Jurassic, and Cretaceous rocks of Europe, North America, Patagonia, North and South Africa, India, and Australia. The distribution of the *Ceratodontidæ* has therefore been, at different periods at least, a world-wide one, and we should feel justified in assuming the living representatives of the *Lepidosirenidæ* to have been evolved out of this family independently in Africa and in South America. On the other hand, in view of the old age of the group, there is no reason why the *Lepidosirenidæ* should not have passed from one of the present continents into the other when they were connected by land. As *Protopterus* is a less specialised type than *Lepidosiren*, the probabilities would then be that the former originated in Africa. Mr. Lydekker, in his 'Geographical History of Mammals,' states his opinion that *Lepidosiren* reached its present habitat by way of Africa. The mode of life of these fishes renders them less dependent on hydrographical systems, and the distribution of the species, which cannot yet be traced in a satisfactory manner, is evidently very different from that of other groups. In this case, again, Mr. Moore has appealed to *Protopterus* as probably representing, with *Polypterus* and most of the *Cichlidæ*, the 'now scattered piscian portion of the halolimnic fauna' of Tanganyika. He, however, omits to mention that this fish is not known to occur in the lake itself, but is only reported to be found in some marshes in its vicinity, the species being the same as that which extends northwards to the White Nile; it should therefore not be included at all among the inhabitants of Lake Tanganyika.

THE MORMYRIDÆ.—This extraordinary group, of which so many new and remarkable types have been discovered within the last few years, especially in the Congo, is peculiar to the fresh waters of Tropical Africa and the Nile. Its morphology shows it to be highly specialised from some very lowly Teleostean ancestor. This I believed to be found in the *Albulidæ*, a family already represented in Cretaceous seas, and of which one species still occurs on the West Coast of Africa. But Dr. Ridewood, who has recently made a much more careful study of the cranial characters of the two families, is unable to support the suggestion of a direct descent from the *Albulidæ*. It nevertheless remains probable that the *Mormyridæ* were derived from forms more closely allied to the known *Albulidæ* than to any other family with which we are acquainted, and which no doubt lived in Cretaceous seas; and we may therefore assume that the *Mormyridæ* originated in Africa, and were evolved out of Cretaceous marine ancestors.

THE NOTOPTERIDÆ.—This is another eccentric family, having many points in common with the *Mormyridæ* and with the North American *Hyodontidæ*. It is represented by five species, three of which live in the Indo-Malay region and two in Tropical Africa. Its derivation is still a mystery. The fact that its most specialised form (*Xenomystus*) is African, and that a species differing but little from the living *Notopterus* occurs in fresh-water deposits in Sumatra, which are regarded by some geologists as of Middle Eocene age—although, as stated further on *à propos* of the *Cyprinidæ*, there is reason for regarding them as Miocene, or even later—justifies us in believing, until further palæontological evidence be available, that the African forms are immigrants from the East.

THE OSTEOGLOSSIDÆ.—An archaic type of Teleosteans, now represented by two genera in South America, by one in Australia and the Malay Archipelago, and by a fourth in Tropical Africa and the Nile. Excellently preserved fossils from the Middle Eocene of Wyoming (*Dapedoglossus*) are most nearly allied to, but more generalised than, the Australian-Malay genus; whilst the less

satisfactorily known British Lower Eocene *Brychætus* appears nearer to the South American *Arapaima*. The African genus *Heterotis* is the most specialised form. The *Osteoglossidæ* are evidently an ancient group, now in process of extinction, which once had a very wide distribution. The fact of the only known fossil representatives being from North America and Europe does not seem sufficient evidence of the northern origin of the family, as suggested by Mr. Lydekker.

PANTODONTIDÆ, PHRACTOLÆMIDÆ, CROMERIIDÆ.—Three monotypic families peculiar to Africa. The first bears a near relationship to the *Osteoglossidæ*, and was probably derived from them; but the two others, discovered within the last few years, are so aberrant and isolated among the Malacopterygians that we are absolutely in the dark as to their possible origin.

THE CHARACINIDÆ.—This is one of the larger groups of African fishes—with ninety-three species, referred to twenty genera, mostly from the Nile and Tropical Africa, as far east as the great lakes, but only very sparsely represented in East and South Africa.

One of the most striking features of the South American fresh-water fish-fauna is the extraordinary number and variety of forms of the *Characinidæ*, unquestionably one of the most lowly and generalised groups of exclusively fresh-water Teleosts. There occur in that part of the world as many as 500 species (about two-fifths of the whole fresh-water fish-fauna), divided among some sixty genera. The carnivorous forms predominate, but the herbivorous or semi-herbivorous are also very numerous. The latter would evidently compete with the Cyprinids, their near but more specialised relatives, which are so numerously represented in North America; and it is a remarkable fact that not a single Cyprinid is known to extend further south than Guatemala.

Although palæontology has taught us nothing respecting the Characinids, we have reason to assume, from the morphological point of view, that they were the precursors of the Cyprinids, which, we know, were already abundantly represented in North America and Europe in Lower Tertiary times, when the Isthmus of Panama was under the sea. When, in the Miocene, North and South America became reunited, the waters of the latter part of the world must have been already so fully stocked with Characinids as to prevent the southern spread of the Cyprinids. This is the only explanation that can be offered of the total absence of Cyprinids in South America, considerations of climate being of no avail in view of their distribution all over Africa. If, therefore, the Characinids existed in profusion in South America before the Miocene period, we are justified in claiming for them a high antiquity, and by putting it at the Upper Cretaceous we need not fear going too far back. As it is admitted by most geologists that a continuous land communication probably existed across the Atlantic between South America and Africa up to the end of the Upper Cretaceous period (not, however, in the position designed by Dr. Ortmann, as is proved by the recent discovery of Turonian beds in the French Soudan, in Nigeria, and in Cameroon), it is legitimate to explain the distribution of the *Characinidæ*—Africa and Central and South America—by such a bridge. This explanation tallies well with the fact, pointing to a severance from remote times, that, although the Characinids of the old and new worlds show near affinity, no single genus is common to both. The further fact that the most generalised genera (*Erythrininæ*) are now found in America points to the African forms having migrated from the West.

When, at some time during the later part of the Cretaceous period or at the dawn of the Eocene, the Characinids reached Africa, and established themselves in the western and central waters, there were no Cyprinids to compete with them; but their spread to the east was soon checked by the invasion of the latter from the north-east; further, by the time they reached East Africa the bridge to Madagascar had ceased to exist.

On the other hand it is quite true that, as pointed out by Mr. Lydekker, the blank in the palæontological record can scarcely be taken as a sufficient indication that the family *Characinidæ* has always been a southern one.

THE CYPRINIDÆ.—These fishes, as mentioned above, are very closely related to the preceding, and there is every reason to believe the former to be derived from the latter. Their least specialised genera (*Catostominæ*) are now found in North and Central America (about sixty species), whilst three species, referable to the same genera, inhabit Eastern Siberia and China. These *Catostominæ* are known to have had representatives in the Eocene of North America, whilst the more specialised *Cyprininæ*, which constitute the great bulk of the family both in the new world and in the old, have left remains in the Oligocene and later beds in North America and Europe. It is, therefore, highly probable that the Cyprinids originated as a northern offshoot of the South and Central American Characinids, and thence spread to Eastern Asia, at least as early as the Upper Eocene. By the time (Miocene) they had reached India, where they now form the great majority of the fresh-water fishes, Africa had been connected with it by a wide belt of land, and no obstacle prevented their western extension. This comparatively recent migration accounts for the practical identity of the genera and the often very close affinity of the species of the Cyprinids of India and Africa. At the same period the land-area connecting India and Africa with Madagascar had disappeared, and the Cyprinids never reached that great island, where no doubt they would have thriven, if we judge by the results of the introduction by man of the gold fish, said to be in process of strongly reducing the numbers of the native Malagassy fresh-water fishes with which it is in a position to compete. Competition is always an important factor in the distribution of a group of animals, and the confinement of the Characinids to the waters of the western and central parts of Africa at the time of the immigration of the Cyprinids from the east must be the explanation of the comparative abundance of the latter and the scarcity of the former in those parts of the continent east of the Rift Valley which are not drained by rivers flowing from the central parts. The Cyprinids must have spread more rapidly than the Characinids, and being also less partial to heat they have thriven in the waters of South Africa, where at present only two species of Characinids—both carnivorous forms—are known to extend south of the Zambesi system. Of the 202 species recorded from Africa thirteen are found in North-West Africa, sixty-three in East Africa (exclusive of the Zambesi), and twenty-one in South Africa.

THE SILURIDÆ.—This large family is almost cosmopolitan in tropical and warm regions; and although the great bulk of the species are restricted to fresh waters, a certain number (chiefly of the sub-family *Ariinæ*) occur on the coasts and in the estuaries. Morphologically these fishes are so closely allied to the Characinidæ and Cyprinidæ that we must assume them to have been evolved from a common ancestral stock, probably in Cretaceous times; but connecting forms such as we should expect to find in deposits of that age are still unknown. The Silurids appear in the Lower Eocene estuarine beds of England and France, as forms closely related to the living *Ariinæ* and *Bagrinæ*, and further allied forms follow in the Middle Eocene of various parts of Europe and North America. In the Upper Eocene of Lower Egypt estuarine deposits contain well-preserved remains of forms which appear to be only specifically separable from the *Bagrus* still living in the Nile.

The general distribution of these fishes was, therefore, in early Tertiary times very much the same as it is at present, and palæontology offers us no clue as to where they originated. The most generalised Silurid known at present (*Diplomystus*) is now living in South America. The resemblance between certain African and South American genera placed together under the sub-family Doradinæ might suggest a former communication between these parts of the world; but we must bear in mind that the same sub-family is also represented in South-Eastern Asia, and as far back in time as the Miocene (*Bagarius gigas*). Leriche, who has recently reviewed our knowledge of the fossil Silurids, follows Verbeck in regarding the Padang lignites whence Günther described this *Bagarius* and other fresh-water fishes as Middle Eocene; but at that time, according to de Lapparent, Sumatra was entirely under the sea; and Dr. Smith Woodward agrees with me in thinking that the beds in question must be more recent than Eocene.

The exclusively fresh-water Silurids now found in Africa are all generically distinct from the South American forms, whilst the West African species that enter the sea belong to the same genus (*Arius*). This consideration seems to me o speak against any continental extension across the Atlantic later than the earliest Tertiary times, and so does the fact that the Middle Eocene forms found in Egypt, and recently described by Dr. Stromer, differ so little from their existing representatives, *Bagrus* and allies. On the assumption of a late Eocene or Miocene Atlantic, we should expect to find a much closer relationship between the American and African strictly fresh-water fishes than exists at the present day, whereas only those forms that are known to enter the sea are generically identical in those two parts of the world.

The two exclusively fresh-water Silurids found in Madagascar show closer affinity with the African than with the Indian forms, and may have immigrated from Africa in the early Tertiary times through the bridge which then existed, unless they have been derived from marine types, which is quite possible.

THE GALAXIIDÆ.—Two small fishes originally described by F. de Castelnau as Loaches, and now referred to *Galaxias*, occur on the flats near Cape Town and in the Lorenz River, some twelve miles from its mouth in False Bay. They are of special interest as belonging to a family and genus long believed to be exclusively confined to fresh waters and characteristic of the extreme south of America, New Zealand, and Southern Australia. After Dr. Steindachner had first recognised the true affinities of the Cape species, Professor Max Weber was inclined to regard this interesting discovery as affording a new argument in favour of the past antarctic continent on which so much has been written. But Dr. Wallace was nearer the truth when he suggested that a land connection within the period of existence of one species of fish, viz., *Galaxias attenuatus*, known from Chili, Patagonia, Tierra del Fuego, the Falkland Islands, New Zealand, and Southern Australia, would have led to much more numerous and important cases of similarity of natural productions than we actually find, and that we must rather look to the transport of the ova across the southern sea to explain this very remarkable distribution. A better acquaintance with the *Galaxias* has confirmed Dr. Wallace's supposition, as it is now an established fact that some species live in the sea. *G. attenuatus* has been observed in the Falkland Islands and in New Zealand to descend periodically to the sea for the purpose of spawning. No doubt the early *Galaxias* lived in the sea, and the Cape species, like many others, only afford examples of originally marine forms having settled in fresh waters. Curiously, at the other extremity of Africa the same thing has happened in the case of several small fishes pertaining to three different families—the *Gobiidæ*, the *Blenniidæ*, and the *Syngnathidæ*—to say nothing of such types as the Trout and the Stickleback, the presence of which in Algeria, were it not proved that land communication between Southern Europe and North-West Africa existed up to very recent times, could be accounted for by a direct marine ancestry, as shown by their nearest relations.

As the early Tertiary 'Antarctica,' as designed by Professor H. F. Osborn, does not involve South Africa, the presence of species of *Galaxias* at the Cape cannot, even on that hypothesis of continental extension, be explained except on the assumption of their marine origin.

THE KNERIIDÆ.—A monotypic family with two species, one from Angola, the other from East Africa. These little fishes are related to the Pikes, *Esocidæ*; and there is no reason that I can see against their being possibly derived from them, in which case they would be of northern origin, the *Esocidæ*, now confined to the northern hemisphere, being known from fresh-water deposits in Europe as far back as the Oligocene.

THE CYPRINODONTIDÆ.—The members of this large family are mostly Central and South American. They are comparatively few in Africa, but have representatives in every part, and also in Madagascar and the other islands of the Indian Ocean. Although principally restricted to fresh waters, not a few species are

known to live in brackish water, whilst examples are known of their occurring far out at sea. Under these circumstances the wide range of the principal African genera—*Cyprinodon*, S. Europe, S.W. Asia, N. Africa, North and South America, *Haplochilus*, Africa, S. Asia, Japan, North and South America, and *Fundulus*, S. Europe, Africa, North and South America—is not surprising. *Cyprinodon* is probably an immigrant from the North—where its close ally *Prolebias* was abundantly represented in the Oligocene and Miocene of Europe—whilst *Fundulus* and *Haplochilus* may have reached Africa by the sea.

The Ophiocephalidæ and Anabantidæ.—Unknown fossil, and now restricted to Africa and South-Eastern Asia, we have no means of telling in what part of the world these two closely allied families originated. The *Anabantidæ* are more numerous in species, and these are of a more generalised type, in Africa than in Asia.

The Nandidæ.—The recent discovery of *Polycentropsis* in the Lower Niger has added a genus to a small family previously known to be represented by three genera in South-Eastern Asia and by two in the northern parts of South America. The latter are more nearly related to the African genus than the former. Too little is known of the habits of these fishes to decide whether the hypothesis of a migration across the Atlantic, in the days when a shallow area with a string of islands connected the old world and the new, answers for their distribution. Their systematic position—specialised Perciformes—is against the assumption of their having existed in Cretaceous or early Eocene times. No fossil forms are known.

The Osphromenidæ.—The only African representative, the genus *Micracanthus*, with a single species in the Ogowe, is hardly separable from the genus *Betta*, which, with six other genera, is characteristic of the Indo-Malay region and China. Palæontology gives no information on the earlier distribution of these highly specialised fishes. That a type so well organised for adapting itself to all sorts of waters, and so ready to acclimatise itself in any part of the tropical or subtropical countries where it has been transported by man, should have so restricted a range seems remarkable. Were it not for the existence of this African form, far away from the other members of the family, one might have felt inclined to look upon the Osphromenidæ as a very recent group, which has not had time to spread far from its original centre in South-Western Asia.

The Cichlidæ.—As regards the number of species (179) this family ranks next to the *Cyprinidæ* (202) and the *Siluridæ* (187) in the African fresh-water fish-fauna, and, like these, it has representatives nearly all over the great continent. Although Cichlids may thrive in inland waters of considerable salinity, they are not known to have ever been found in the sea, even near the mouths of rivers. The facility with which they establish themselves in isolated waters, often untenanted by other fishes, such as wells in the Sahara, salt-water pools in the interior of East Africa, &c., has long been known, but by what agency this has been effected remains unexplained. Quite recently Dr. Lönnberg has reported on the exploration of a small isolated lake of volcanic origin on the Cameroon mountain, a lake 200 feet above sea-level, without any outlet, and situated about twelve miles from the nearest river and twice as far from the sea-shore. This lake was found to have a fish-fauna consisting exclusively of Cichlids, belonging to three genera and five species, two of which have been described as new.

The great bulk of the family inhabits Africa, including Madagascar, and America, from Texas to Montevideo; the number of generic types is greater, although the species are only slightly in excess, in the former than in the latter part of the world. Seven species inhabit Syria, three of these being also found in the Nile, and three are known from India and Ceylon. The American and Indian genera are all distinct from the African. A great number of species (fifty-five), all but one endemic, inhabit Lake Tanganyika, of which they form a little over two-thirds of the fish-fauna; and many of these species belong to distinct genera,

showing specialisation to a remarkable degree. Out of thirty recognised genera of African Cichlids, as many as fifteen are believed to be peculiar to Tanganyika. Lake Nyassa, with the Upper Shiré, possesses also some remarkable endemic genera; but they are only four in number, and the number of species recorded up to the present does not exceed twenty-two. The rest of the species are mostly from West Africa and the Congo basin; but a few, referable to the two most widely spread genera, are found in East and South Africa. Madagascar has only four species, two belonging to an endemic genus, whilst each of the two others is referred to a widely distributed African and Syrian genus.

No fossils are known that agree closely with any of the recent genera, but a type of Perciforms, described by Cope as *Priscacara*, from Middle Eocene freshwater beds in North America, presents all the characters which we should expect to find in the direct ancestors of the modern Cichlids, differing from the living forms in the presence of vomerine teeth, a serrated præ-operculum, and apparently eight branchiostegal rays. It has twenty-four vertebræ, a number lower than is found in most of the recent genera; and this indication is of importance for reasons that must be explained somewhat fully.

The lower Teleosteans (Malacopterygii and Ostariophysi, often united under the term 'Physostomi') mostly have a high number of vertebræ; but when we pass on to the higher Acanthopterygii, we find very frequently, among most diverse families, the number reduced to twenty-four. That this number should occur with such frequency has struck many ichthyologists since Dr. Günther first drew attention to it, over forty years ago, pointing out at the same time that in the *Labridæ* this number is almost constant in the tropical genera, whilst those genera which are chiefly confined to the temperate seas of the northern and southern hemispheres have an increased number. It has since been shown by Dr. Gill and by Professor Jordan that this generalisation holds true of several other families of Acanthopterygians, and the latter authority, when discussing the subject at some length, came to the opinion that the state of things could be explained, from an evolutionary point of view, on the assumption that competition among various marine fishes being greater within the tropics has resulted in greater specialisation, by which the originally high number of vertebræ has been reduced. It is difficult, however, on this assumption to account for the fact that in so many cases the reduction should have resulted in the number twenty-four—neither one more nor one less—and this repeated in many families belonging to the same sub-order but otherwise only remotely related to one another. Three years ago, when dealing with the affinities of the Flat-fishes, *Pleuronectidæ*, I was struck by the discovery that, in the unquestionably least specialised genus, *Psettodes*, the vertebræ are twenty-four in number, the other known genera having from twenty-eight to sixty-five, and that the numbers increased along the most probable lines of evolution. A consideration of other families, and of the fossil forms in which the number of vertebræ has been ascertained, soon convinced me that this rule also applies to them, and that the order of evolution had in every case to be reversed from that assumed by Professor Jordan, whose interpretation I had previously accepted as correct. As a result of my investigation into this question I believe that the frequent occurrence of twenty-four vertebræ is due to the original Acanthopterygians having presented this number, that it has been retained in the more generalised members of the families which have branched off from them, and increased or, more seldom, reduced in the course of evolution. This opinion is supported by the available palæontological data, several of the Cretaceous *Berycidæ* (*Beryx*, *Hoplopteryx*), the earliest Acanthopterygians, having twenty-four vertebræ, and the same number occurs in the Cretaceous *Scorpididæ*; *Prolates*, the earliest true Perciform, from the lowermost Eocene beds, formerly ranked as Upper Cretaceous, has the same number. Several other families afford good support to this theory: In the *Echeneididæ*, the Eocene *Opisthomyzon* has twenty-four vertebræ, the living *Echeneis* twenty-seven to thirty; again, the earliest known Cottid, the Eocene *Eocottus*, has twenty-four, the Oligocene-Miocene *Lepidocottus* twenty-six, whilst the living members of this large family have no fewer than thirty; the earliest known Blenniid, *Pterygocephalus*,

from the Eocene, has twenty-four vertebræ, its nearest living allies, *Clinus* and *Cristiceps*, having at least thirty-four. Even the *Scorpænidæ*, one of the families on which Professor Jordan based his theory, and in which the vertebræ vary from twenty-four to thirty-seven in living genera, confirm my conclusion, since their Eocene precursor, *Ampheristus*, has the lower number. I might mention other examples, derived from the living *Scombriformes* and *Perciformes*, to show that evolution must have proceeded in the same way.

Things being so, the view which I entertained when first studying the Cichlids of Lake Tanganyika must be abandoned, and the direction of the supposed lines of evolution reversed, together with the signification given by me to the characters of increased number of dorsal and anal rays, or of multiple lateral lines which go more or less hand in hand with the increase in the vertebral segments. I must therefore repudiate the statement, first made by me in describing some of the new genera discovered by Mr. Moore in Lake Tanganyika, that they show features of generalisation, the contrary being the case. This has been shown by Dr. J. Pellegrin, who has recently published a monograph of the whole family *Cichlidæ*, in which he has very ably dealt with the question of the interrelation of the various genera from the phylogenetic point of view.

Two theories have lately been put forward as to the origin of the African Cichlids.

According to Mr. Moore, to whom we owe the discovery of so many new forms in Lake Tanganyika, the Cichlids are of marine origin, and penetrated into a hypothetical Central African sea in præ-Tertiary times. But as no Perciform fish of any sort is known earlier than the Upper Cretaceous, and no Perch, in the widest sense, before the Lower Eocene (*Prolates*), the possible existence at that remote time of so specialised a type of Perches as the Cichlids is absolutely contrary to palæontological evidence. Further, such an explanation is unsupported by any geological data, no trace of Jurassic or Cretaceous deposits having been found on the plateau of Central Africa, notwithstanding much search over a considerable portion of the Congo State. It is impossible to imagine that such a sea could have existed without leaving any sedimentary deposits whilst its relics were being preserved in Lake Tanganyika. Besides, the distinguished Belgian geologist, Professor J. Cornet, who has paid special attention to this question, and has himself surveyed a considerable part of the territory of the Congo State, regards the Tanganyika as by no means a very ancient lake, its formation not dating back beyond Miocene times. I may also here point out that Mr. Moore's interpretation of the affinities of the so-called 'halolimnic' Mollusca have not received any support from those best able to judge of its merits. Mr. E. A. Smith, from the recent conchological, and Mr. Huddleston, from the palæontological point of view, have recently discussed his conclusions, with which they are unable to agree. I need hardly add that the discovery since the publication of the 'Tanganyika Problem' of the Medusa *Limnocnida tanganicæ* in Lake Victoria has dealt a further blow to Mr. Moore's theory.

As regards the origin of this Medusa, recent palæontological discoveries afford a much more rational explanation of the presence in Tanganyika of a Cœlenterate of unquestionably marine derivation. The highly important finds of fossils between the Niger and Lake Chad by the English and French officers of the Boundary Commission, which have been reported upon by Professor de Lapparent, Mr. Bullen Newton, and Dr. Bather, have conclusively established the existence of Middle Eocene marine deposits over the Western Soudan, and the Egyptian and Indian character of these fossils, as well as of others previously obtained in Cameroon and Somaliland, justifies the belief in a Lutetian (Middle Eocene) sea extending across the Soudan to India. In fact, as stated by Mr. Newton, the palæontological evidence seems to prove that the greater part of Africa above the equator was covered by sea during part of the Eocene period. On this sea retreating northwards, after the Lutetian period, Medusæ became land-locked and gradually adapted themselves to fresh water: they had not far to travel to find themselves in what are now the Nile lakes, and later, through the changes which Mr. Moore himself has shown to have taken place in the drainage of Lake Kivu,

they were easily carried into the Tanganyika—probably at no very remote time—and maintained themselves to the present day. I understand that the Medusa reported from Bammaku, Upper Niger, in 1895, but still undescribed, has been rediscovered by Budgett, and is now being studied. Should it prove to be related to the Tanganyika species, it would also have to be regarded as a relic of the same Eocene sea, and it would add further support to the very simple explanation which I have ventured to offer of a case which seemed so tremendously puzzling in our previous state of ignorance of the geological conditions of Africa between the equator and the tropic of cancer.

As explained by Professor Cornet, Tanganyika has been until very recent times without an outlet. The Lukuga, which drains into the Congo, was only formed after Lake Kivu became, owing to volcanic eruption, a tributary of the Tanganyika through the Rusisi River. The greater or less salinity of the water of a lake without an outlet is a matter of course, and therefore Tanganyika was for a long time a salt lake. Its water is still, Mr. Moore says, somewhat salt. No wonder that the Cichlids, which elsewhere in Africa show no aversion to such conditions, and which somehow or other contrive to settle into isolated waters, should have been among the first inhabitants of the lake, where, without having to face competition with other types of fishes, they throve and became differentiated into a multitude of genera. When the hydrographical conditions changed and the water gradually lost its salinity, first on the surface and later at greater depths, an influx of other forms of fish-life (*Polypterus*, Characinids, Cyprinids, Silurids, &c.) penetrated into the lake, some from the Nile system through the Rusisi, others from the Congo up the Lukuga. This explains well enough the character of the Tanganyika fish-fauna. The Cichlids, the oldest inhabitants of the lake, nearly all belong to endemic species, many of which constitute genera represented nowhere else; whilst the fishes of other families, later immigrants, all belong to widely distributed genera, and several of them even to species also found either in the Nile or in the Congo, or in both these river-systems.

The other theory is that the Cichlids have originated as fresh-water fishes in Eocene times in America and have crossed the Atlantic by a bridge which then connected South America with Africa. This is the explanation given by Dr. Pellegrin. He admits that we have no indication of any near allies of these fishes before the Middle Eocene (Green-River beds of North America), and, basing his statement on the last edition of Professor de Lapparent's 'Traité de Géologie' (1900), he says it seems to be beyond doubt that during the Lutetian period, which immediately followed that at which the earliest Cichlids were known to live in the fresh waters of America, a vast continent extended between South America and Africa. Should this have really been the case, the question of the distribution of the Cichlids could be regarded as settled. But I cannot satisfy myself that there is any geological evidence to support this view. That a shallow sea with a chain of islands connected the West Indies with the Mediterranean in Middle Eocene times is generally believed, and this theory is supported by serious arguments; but a series of islands would hardly be sufficient for the passage of fresh-water forms, such as we have reason to think the Cichlids have always been. In his maps of distribution Dr. Ortmann does not support Dr. Pellegrin's assumption. Professor de Lapparent has kindly informed me that his map of the Lutetian period requires very considerable modifications owing to the discoveries in the Soudan, in Senegambia, and in Cameroon, to which allusion has been made above; in fact, there is now positive evidence against a Middle Eocene communication between South America and Africa north of the equator. M. de Lapparent still thinks it probable that such a communication may have existed at that period, but it must have been further south; and he admits that this view is hypothetical and rests partly on negative evidence, partly on the peculiar character of the Eocene and Oligocene marine fauna of Patagonia, so different from that of the North Atlantic. Under the circumstances we cannot be too careful in making assertions. Dr. Pellegrin argues that we need not go back beyond the Middle Eocene for the appearance of the first Cichlids in Africa; for some time after, but not later than the Lower Miocene, Madagascar has been, temporarily at least,

joined to Africa; and as the Cichlids of Madagascar are essentially African in character, two out of the three genera being identical, we are justified in believing that the Cichlids already existed in Africa at some time between the Middle Eocene and the Lower Miocene. But then what about the Indian and Ceylonese species of the genus *Etroplus*, which are not so closely allied to *Paretroplus* of Madagascar as was formerly believed? The land-area which once connected Madagascar direct with India had ceased to exist in Lower Tertiary times, and we must therefore assume that the Cichlids reached India from Africa through South-Western Asia, which is quite possible, or else that they are immigrants from the North. The latter supposition would harmonise with what I believe may have been the original mode of dispersion of this family on the assumption that the North American Middle Eocene *Priscacara* really represent the ancestral stock of the Cichlids. These fishes would have ranged over North America and Northern and Eastern Asia, which were then one continent. That we have no palæontological evidence of this distribution there is no wonder, since we know nothing of Eocene fresh-water fishes on the Asiatic continent; and when, later, India and Africa became connected with the Asiatic-American continent, they migrated southwards and westwards, and for climatic and other reasons at once flourished in and spread all over Africa, and especially in the newly formed Lake Tanganyika.

This third hypothesis has this advantage over the two others, that it does not postulate any land-areas in late Eocene or Miocene times, for which there is at present no sufficient evidence, nor a præ-Tertiary and marine origin for the family Cichlidæ, which is wholly improbable and receives no support from palæontology.

On the other hand, it is undeniable that the hypothesis of a South Atlantic land communication in the Eocene has much in its favour, and when this is really established all difficulty in explaining the distribution of the Cichlidæ will have disappeared. In the meanwhile, to use an appropriate metaphor, we must not construct bridges without being sure of our points of attachment, otherwise they are liable to collapse as geological knowledge progresses.

The Mastacembelidæ.—In dealing with the distribution of fresh-water fishes in his 'Introduction to the Study of Fishes,' Dr. Günther has observed that 'as a general rule a genus or family of fresh-water fishes is regularly dispersed and most developed within a certain district, the species and individuals becoming scarcer towards the periphery as the type recedes more from its central home, some outposts being frequently pushed far beyond the outskirts of the area occupied by it.' I do not think there is much to say in favour of this principle, which is often opposed to well-established facts in geological history; and it is interesting in this connection to observe how in the case of the *Mastacembelidæ*, a highly specialised family akin to the Acanthopterygians, and possibly derived from the *Blenniidæ*, recent discoveries have reversed the state of things that appeared at the time Dr. Günther drew up his conclusions. '*Mastacembelus* and *Ophiocephalus*, genera characteristic of the Indian region,' he says, 'emerge severally by a single species in West and Central Africa'; and, further, when comparing the fishes of the Indian and African regions, he adds: 'A few species only have found their way into Africa.' At present we are acquainted with thirty-eight species of *Mastacembelus*: fourteen from the Indo-Malay region, one from Syria and Mesopotamia, and twenty-three from Tropical Africa. The distribution of these fishes, the fossil remains of which are still unknown, has probably once been a continuous one, climatic and hydrographic conditions possibly accounting for the present discontinuity. We have no data from which to decide whether the Mastacembelids first appeared in Asia or in Africa, or simultaneously in both parts of the world, as is quite possible on the assumption that the family originated in the Eocene sea extending from the Western Soudan to India.

This concludes our review of the affinities and past history of the principal fresh-water types which characterise the present African fish-fauna. We have

endeavoured to show that a Tertiary land connection between Africa and South America is not absolutely necessary to explain the many points of agreement between the fresh-water fishes of these two parts of the world, as has been postulated by many writers. Besides, there are still some who hold, as does Professor G. Pfeffer—whose interesting essay on the zoo-geographical conditions of South America, from the point of view of lower vertebrates, appeared after this Address had been written—that a former subuniversality of distribution will afford a solution to many of these problems without necessitating such a land-connection, as exemplified by the past distribution of the Pleurodiran Chelonians. In this review we have summarised many previous hypotheses and added a few, but in every case with a feeling of dissatisfaction, fully realising, as we do, the futility of speculations in the present state of the two great branches of knowledge, geology and palæontology, on which the solution of these questions must ultimately rest.

We may now pass on to the realm of facts, and survey in the briefest manner the waters of the great continent as they appear after the many discoveries which have of late so greatly increased our knowledge of the African fishes. Much, very much, remains to be done before we can claim an approximately sufficient acquaintance with the faunas of the different districts, so many of which are still unexplored as far as fishes are concerned. But we have reason to rejoice at the rate at which our knowledge has progressed within the last few years, and I may here pay a tribute of gratitude to the many explorers who, among hardships and dangers of all kinds, have found it possible to devote some of their energy to the collecting of fishes, a group of animals which offers special difficulties of preservation and transport. Among those who have done most in this line within the last ten years I must mention the names of Mr. Moore of Tanganyika fame and his successor in the same field, Mr. Cunnington; Mr. Loat, whose three years' fishing in the Nile has resulted in a splendid collection, now being worked out under the auspices of the Egyptian Government in response to an appeal from the late Dr. John Anderson; Captain Wilverth, Major Cabra, Captain Lemaire, Captain Hecq, and other Belgian officers in the service of the Congo State; Mr. G. L. Bates, who is still adding to our knowledge of the South Cameroon and Gaboon districts; the late Miss Kingsley, who collected in the Ogowe; Captain Gosling, who has sent home a fine series of the fishes of Lake Chad; Dr. Ansorge, who, after making important discoveries in the Niger Delta, has passed on to the exploration of Angola; Mr. Degen, in Abyssinia; Dr. Donaldson Smith, Mr. Hinde, Mr. B. Percival, Mr. Oscar Neumann, and the late Baron Carlos von Erlanger, in East Africa; and, lastly, three who have sacrificed their lives in the service of zoology: Paul Delhez (Congo, Senegal), Doggett (Lake Victoria), and J. S. Budgett, to whose loss I have already alluded.

Here in South Africa, through the generosity of Mr. C. D. Rudd, a systematic zoological survey, which promises to yield important results, is now being carried out by Mr. C. H. B. Grant, formerly of the British Museum, who has proved himself to be a most painstaking and successful collector.

In the present state of our knowledge of the fresh-water fishes Africa may be divided into five sub-regions, the discussion of the further subdivision of which would exceed the limits of this Address:—

1. The North-Western Sub-region, or Barbary, and the Northern Sahara, properly forming part of the Palæarctic region.

2. The Western-Central Sub-region, with all the great rivers and lakes, extending to the Nile Delta and the mouth of the Zambesi, for which the term Megapotamian Sub-region has been suggested to me by Dr. Sclater.

3. The Eastern Sub-region—Abyssinia, with the upper tributaries of the Blue Nile, and the countries east of the Rift Valley and north of the Zambesi.

4. The Southern Sub-region—all the waters south of the Zambesi system.

5. Madagascar.

The smaller islands of the Indian Ocean have a fresh-water fish-fauna so insignificant that they may be entirely neglected in a broad division of the African region.

I. The North-Western Sub-region.

In its deficiency in rivers of permanent flow Barbary has much in common with South Africa, and these two parts of Africa in their fish-fauna present a somewhat analogous example to that on which the now exploded theory of bipolarity was founded. Swelling to foaming torrents in the rainy season or after a storm, reduced to series of pools connected by tiny streams at other times, the watercourses are evidently unsuited to fish-life; and it is not surprising that, apart from a certain number of forms adapted to live in stagnant, often strongly saline, waters, the fishes should be so few in kinds. But they make an interesting assemblage, in which it is easy to discover forms unmistakably suggestive of the præ-Pliocene times when the sea had not burst through the Straits of Gibraltar, mixed with others of decidedly Africo-Indian or Oriental affinities.

The number of species from inland waters, whether fresh or salt, hitherto recorded from this part of Africa, amounts to thirty or thirty-one only. Of these thirteen are Cyprinids, which may all be regarded as of northern or eastern immigration. Four of the Barbels show European affinities, one of them being found also in Spain, whilst the seven others belong to a section of the genus largely represented in Southern Asia and East Africa, but only known in West Africa from Cameroon. A species of *Varicorhinus*, recently discovered in Morocco, has similar affinities, the genus being known from South-Western Asia, Abyssinia, and Lake Tanganyika. A small somewhat aberrant species of the South-Western Asian genus *Phoxinellus* has been described from the Algerian Sahara, whilst an *Alburnus* from the Tell (originally placed in the genus *Leuciscus*) is also the sole representative in Africa of a genus inhabiting Europe north of the Pyrenees and Alps and South-Western Asia. With two exceptions, all the Cyprinids are confined to the northern watershed of the Atlas, in which varieties of our River Trout and our Stickleback also occur; but *Barbus callensis* and the *Phoxinellus* occur also in the Algerian and Tunisian Sahara, showing that, as in other groups of animals, no sharp delimitation can be drawn between the Palæarctic and Æthiopian regions of Barbary.

Of three Cyprinodonts one, from the high plateaux, inhabits also Spain; another, more generally distributed, is known from Sicily, Syria, and North-East Africa; whilst the third, remarkable for the absence of ventral fins, is monotypic of a genus named *Tellia*—a misnomer, as it is not found in the Tell, but on the high plateaux of Algeria, at altitudes of from 2,000 to 3,000 feet, not 8,000, as stated by Dambeck.

Three Cichlids are known from the Northern Sahara, one, a *Tilapia*, being restricted to Eastern Algeria and Tunisia, whilst the two others, a *Hemichromis* and a *Tilapia*, extend to Lower Egypt, and are besides widely distributed in Tropical Africa. The Cichlids, along with the *Cyprinodon*, the *Barbus*, and the *Phoxinellus* mentioned above, are often ejected by artesian wells, and the fact has given rise to much discussion. The latest investigator of this phenomenon, the distinguished engineer, M. George Rolland, confirms the opinion, expressed by the late Sir Lambert Playfair and M. Letourneux in 1871, that these fishes normally live and breed in the lakes and wells exposed to air and light, and that their presence in the underground sheets of water with which the lakes communicate is merely an episode, and as it were an incident in the voyages which they undertake from one opening to the other. There is therefore no justification for the term 'realm of the Trogloichthydæ' which has been proposed by Dambeck for North-West Africa.

The other fishes which complete the list are of direct marine derivation, as the anadromous Shad and the catadromous Eel and Grey Mullets, or such as have recently adapted themselves to permanent existence in fresh water, like the *Syngnathus* discovered by Sir L. Playfair, the *Atherina*, which occurs also in various fresh-water or brackish lakes in Southern Europe and Egypt and in the Caspian Sea, two Gobies and a Blenny, the latter being also known from fresh waters in the South of France and in Italy. The occurrence of an otherwise

strictly marine species of Blenniids (*Cristiceps argentatus*) in the fountain of Ain Malakoff, in the high plateaux of Algeria, rests on the testimony of a naturalist of Algiers and needs confirmation.

Before leaving this part of Africa I cannot refrain from alluding to the fact that when Canon Tristram obtained specimens of the Cichlids *Tilapia zillii* (then named *Haligenes tristrami*) in the salt-water marshes of the Wed Rhir nearly fifty years ago, he thought he had added a further argument to the then prevalent theory of the Sahara being the bed of an evaporated Tertiary ocean, these Cichlids being regarded by him as relics of a former marine fauna. It is not without interest to recall this expression of opinion, which Canon Tristram has since repudiated, as a parallel to the hypotheses which have of late been so lightly adduced in the case of this same group of fishes in Lake Tanganyika.

II. The Megapotamian Sub-region.

The Nile, the Niger, the Gambia and the Senegal, the Congo, and the Zambesi, with their numerous Mormyrids, Characinids, Silurids, and Cichlids, have much the same general character, which points to many of the generic types having radiated from a common centre of origin, no doubt in those great central lakes which are believed to have existed in Middle Tertiary times. Lake Chad, the ichthyic fauna of which was until quite recently unknown, represents the dwindling remains of a larger basin which communicated until comparatively recent times with both the eastern and western river-systems, thus accounting for the great resemblance between the fishes of the Nile and those of the rivers of the Atlantic watershed north of the Cameroons, 46 species out of 101 known from the Nile (without the great lakes by which it is now fed) being also found in the Niger, the Senegal, or the Gambia, or in all three, and most of these have been recently found in Lake Chad and the rivers emptying into it. The collection made in Lake Chad by Captain Gosling, and sent by him to the British Museum, contains representatives of twenty-four species, all of which were previously known from both the Nile and the Niger, thus strikingly confirming conclusions arrived at from a study of the fauna of those two river-systems. Collections sent to the Paris Museum by the Chevalier and Decorse Mission, and worked out by Dr. Pellegrin, add twenty-five species to the above number, two described as new, two Nilotic, eight West African, five Congolese, the rest being common to the eastern and western river-systems. The Congo differs more considerably, and must therefore have been separated from the Nile-Chad-Niger for a longer period, only 15 out of its 265 species (excluding the Tanganyika) occurring also in the Nile, and eleven in the Chad. When we reach the district of the sources of the Congo, the so-called Katanga district, we find a mixture of Congo and Zambesi forms, which points to a former reversal of the drainage of parts of the elevated dividing range. Lake Mwero belongs to this district; although so near to Lake Tanganyika, it has no fish in common with it except a few of very wide distribution. Lake Bangwelo, also in the same district, is said to swarm with fishes, Silurids and Cichlids especially, but they have never been collected. The Zambesi, so far as it has been explored at present, is the poorest in fishes of the great rivers, and it differs from the others in one important point—the absence of the *Polypteridæ.* The great lakes differ considerably in their fishes from the river-systems into which they drain.

As pointed out eleven years ago by Professor Gregory, the system of the head waters of the Nile must have been very differently arranged in times geologically quite recent. This is proved by what we know of the great lakes north of Tanganyika. Thus, of the species known from Lake Victoria, barely one-fourth occur also in the Nile, the rest being mostly endemic; whilst Lake Rudolf, which has now no communication with the Nile, has four-fifths of its species in common with that system. Lakes Albert and Albert Edward are very insufficiently explored and have only yielded a few species, one-half of which are Nilotic. Two fishes, Cyprinids, are all we know from Lake Baringo, one being a widely distributed Nile species, the other an East African. We must conclude

from these data that Lake Victoria has long been isolated, whilst Lake Rudolf has until very recently been in communication with the Nile.

Lake Tsana, which is now the source of the Blue Nile, has recently yielded a large collection of fishes, showing a great variety of Cyprinids, either endemic or identical with species occurring in the eastern watershed, and closely allied to those of Palestine, but with no special Nile affinities. The discovery of a Loach (*Nemachilus*), the first known from Africa, points to an immigration from the Jordan, probably through the old Erythrean Valley. The only species which Lake Tsana has in common with the Nile (*Tilapia nilotica*) occurs also in the Hawash and in the Jordan.

From the vastly increased information we now possess of the fishes of the Nile-system, we are justified in believing in great changes in the hydrography of this part of Africa. The fishes of Lake Tsana would support Professor Gregory's conclusion as to a communication with the Jordan through a river running along what is now the Red Sea, whilst those of the Lower Nile point to a direct communication between the latter and the Jordan, as advocated by Professor Hull, migrations along two distinct channels having taken place at a time when the Mediterranean did not extend so far to the east as it does at present, and the Indian Ocean had not penetrated into the Erythrean Valley. A better knowledge of the fishes of Egypt has disposed of Professor Gregory's arguments against a former communication between the Lower Nile and the Jordan. Quoting Dr. Günther, Professor Gregory, in his book 'The Great Rift Valley,' published in 1896, has laid stress on the supposed facts that *Hemichromis*, a genus of *Cichlidæ*, is not represented in the north-eastern part of Africa, but chiefly on the West Coast and in the central lakes, and that the *Clarias* of the Jordan is not the species of the Lower Nile (*C. anguillaris*), but that of the Upper Nile (*C. macracanthus*), adding that it is of no use, therefore, to assume the existence of a connection between the Lower Nile and the Jordan in order to account for the existence in the latter of fishes which do not occur in the former. These examples were ill chosen, for as regards the *Hemichromis* (including *Paratilapia*) the statement has been disproved by the discovery, in 1881 and in 1903, of two species in Lake Mareotis; and as to the *Clarias* I have been able to convince myself that the species named *C. macracanthus* by Günther is identical with *C. lazera*, a fish common throughout the Nile and over a considerable part of Africa.

The Nile in its widest sense, but without the great lakes, has 101 species, not including those that enter the sea: twenty-seven do not extend north of Chartoum, whilst only six are restricted to the river below the First Cataract. The most important additions made since Dr. Günther's account of them in 'Petherick's Travels' are several Mormyrs, *Barbus*, and *Synodontis*, three Cichlids, a *Xenomystus*, a *Nannæthiops*, a *Discognathus*, a *Barilius*, a *Chiloglanis*, a *Fundulus*, an *Eleotris*, and the remarkable genera *Physailia*, *Andersonia*, and *Cromeria*, the latter the type of a new family.

Thanks to the collections made by Sir Harry Johnston and Col. Delmé Radcliffe, with the help of Mr. Doggett, and by M. Alluaud, supplementing those of Dr. Fischer, we may now draw up a list of twenty-five species from Lake Victoria. The comparative scarcity of animal and vegetable life in this great lake perhaps precludes expectation of a great increase in the number of species in the course of further exploration. Most of the species are endemic and among the most remarkable types may be mentioned a *Discognathus*, a *Mastacembelus* (probably the fish noticed by Grant as a Stickleback), and a peculiar genus of Cichlids, *Astatoreochromis*. No *Polypterus* has yet been found.

Lakes Albert and Albert Edward, recently visited by Mr. Moore, have furnished examples of nine species, mostly Nilotic in character, the most interesting being a *Petrochromis*, on account of its close affinity to a Tanganyika species.

Lake Rudolf, as stated above, differs hardly from the Upper Nile, only three of its sixteen species being indicative of immigration from the East. Not a single form is endemic.

The Senegal must have been very thoroughly explored by Dr. Steindachner thirty-five years ago, as a large collection made a few years since by the late

M. Delhez has not resulted in a single addition to the list of species. The Gambia, on the other hand, is now much better known than it was, thanks to the two visits of the late Mr. Budgett, to whom we owe the discovery of two species. But it is the Niger which, through the collections made by Dr. C. Christy, the late Captain G. F. Abadie, Mr. Budgett, and especially Dr. Ansorge, has been productive of the most important additions to our knowledge. The most striking discoveries are the type of a new family, *Phractolæmus*, since rediscovered in the Ubanghi, and *Polycentropsis*, the first representative of the *Nandidæ* in Africa. Leaving aside species entering the sea, we now know fifty-four species from the Senegal, forty-one from the Gambia, and ninety-six from the Niger, the lower course of the latter being the most productive. A remarkable feature of these rivers is the comparative paucity of Cyprinids, and the total absence in the first two of the genus *Barbus*, which also appears to be absent from the Chad basin.

Our knowledge of the piscine inhabitants of the rivers flowing into the Atlantic between the mouths of the Gambia and of the Niger has also made considerable progress. The fishes of Liberia, collected by Dr. Büttikofer, have been described by Dr. Steindachner, and those of the Gold Coast, collected by the late Mr. R. B. Walker, have been reported upon by Dr. Günther. Sixty-seven species are on record from this district, twenty-four of them being endemic.

Further South, North Cameroon has yielded several additions, for a knowledge of which we are indebted to Dr. Lönnberg, whilst South Cameroon, together with the Gaboon district, has been diligently explored by Mr. G. L. Bates, with the result that a great number of new species have been brought to light. This part of Africa is specially interesting from the fact that its rivers interlock with the head waters of the Sanga, which belongs to the Congo basin, and, the fishes being mostly the same in both watersheds, in that district, a sort of passage is established between the Gaboon and Congo faunas. Among the most remarkable forms discovered by Mr. Bates we may mention the genera *Microsynodontis*, *Allabenchelys*, and *Procatopus*. Since Dr. Sauvage reported, twenty-five years ago, on the fishes of the Ogowe, a small collection has been made by the late Miss Kingsley, and described by Dr. Günther, and a number of new species have been characterised by Dr. Pellegrin. The number of species now known from this part of Africa amounts to eighty-seven for South Cameroon and the Gaboon, and fifty-four for the Ogowe. Very curiously, among them we miss *Polypterus* and *Calamichthys*, which occur in the Lower Niger and Old Calabar, and again in the Chiloango—a remarkable instance of discontinuous distribution, which cannot be accounted for by physical conditions, so far as we are acquainted with them.

The Congo system (exclusive of Lake Tanganyika), from which only about ninety species of fishes were known ten years ago, proves to be far richer than any other, for, incompletely explored as it still is, it has already furnished examples of 265 species, forty-five of which have been added since the publication of the work 'Les Poissons du Bassin du Congo' in 1901. In fact, every collection made even in its most accessible parts adds new species to the list, and many of its rivers have never yet been fished for scientific purposes. No doubt we do not know more than two-thirds of the fishes of the Congo. The riches in Mormyrids, Characinids, Silurids, Cichlids, Mastacembelids, is something surprising, not only in the number of species, but also in their extraordinary variety of structure; and as many as seven species of Polypterids, out of the eleven that are now known, occur in this river-system. With the exception of the *Cromeriidæ* and *Nandidæ*, all the families known from the sub-region have representatives in the Congo.

Lake Tanganyika, now forming part of the same hydrographic system, has a somewhat different fauna, consisting mainly of Cichlids, to which we have specially alluded in an earlier part of this Address. But there are, in addition, a number of Silurids and Cyprinids, a few Mastacembelids and Characinids, a Cyprinodont, and a *Polypterus*. The latter belongs to a species otherwise restricted to the Congo, and of the four Characinids two are Congo and two are Nile forms.

The total number of Tanganyikan species of fishes amounts to eighty-five, but, no doubt, many more await discovery. As I pointed out in reporting on Mr. Moore's second collection, I have reason to think that we do not know more than half of the species of fishes inhabiting this extraordinary lake. The collection which has just been brought home by Mr. Cunnington will greatly add to our knowledge. I may here mention that Mormyrids, which were believed to be absent from Tanganyika, are therein represented by two species.

Lake Rukwa has recently been explored by Dr. Fülleborn, but the fishes, which have been referred to eleven species, belonging to widely distributed genera, have not been studied with a sufficient comparison-material: they appear to be mostly endemic forms.

Lake Mwero has representatives of fourteen species, five of which are endemic, the remainder being found also in the Congo or in the Zambesi, or in both.

The Zambesi, so far as we know it—and its upper parts have scarcely been explored—appears rather poor in fishes, only forty-one species having been recorded. All the genera are also represented in the Congo and in the Nile. Seven of the Zambesi species occur also in Lake Nyassa and the Upper Shiré, whilst in the present state of our knowledge twenty-seven species, mostly Cichlids, may be regarded as endemic to the lake and the Upper Shiré. It is perfectly clear, however, that Lake Nyassa differs far less from the Zambesi than Tanganyika does from the Nile or Congo; and, although the Cichlids are likewise represented by some remarkable genera, they cannot compare for variety with the other great lake the fauna of which has been such a surprise. Both the Zambesi and Lake Nyassa lack representatives of the Polypteridæ.

About forty-five years ago a collection of fishes was made in Lake Ngami, and twelve species were described in a very unsatisfactory manner by the late Count F. de Castelnau; unfortunately the types of these species are lost, and it is difficult to form an idea of their affinities. We know, however, that the lake, which is now rapidly drying up, was then inhabited by a Mormyr, a *Clarias*, a Characinid, and several Cichlids.

The rivers of Angola have been but imperfectly explored. They have yielded a number of Cyprinids and Cichlids, a few Silurids, Mormyrids, and Cyprinodontids, and the type of the remarkable genus *Kneria*, the second species of which inhabits East Africa.

III. The Eastern Sub-region.

As was mentioned in the beginning of this Address, latitude goes for little in the distribution of fish-life. This is proved by the very marked difference in general character of the fish-faunas of Abyssinia and Africa east of the great Rift Valley as compared to the Nile and Central and West Africa. No Polypterids or Mastacembelids, few Mormyrids, Characinids, and Cichlids, but a great number of Cyprinids, mostly *Barbus*, characterise this sub-region. Omitting catadromous forms, the list of fishes consists of one Lepidosirenid, six Mormyrids, eight Characinids, seventy Cyprinids, twenty Silurids, one Kneriid, six Cyprinodontids, and seven Cichlids.

Lake Tsana, with the upper affluents of the Blue Nile, differs very strikingly in its fishes from the Nile, with which it has only two species in common, a Silurid (*Bagrus docmac*), and a widely distributed Cichlid (*Tilapia nilotica*), which occurs also in the Hawash and in Palestine. Nearly all the fishes are Cyprinids, mostly of the genus *Barbus*, which bear close affinity to Syrian types, as does also the recently discovered Loach (*Nemachilus abyssinicus*), so far the only known African representative of that Europæo-Asiatic group. The single species of the Cyprinid genus *Varicorhinus* is also suggestive of South-Western Asia, although a second African species inhabits Lake Tanganyika, and a third has lately been discovered in Morocco. Another Cyprinid genus, *Discognathus*, which is widely distributed over Southern Asia, from Syria and Aden to Burma, is represented by two species, whilst others are known from Abyssinia and East Africa (Gallaland, Kenya, and Kilimandjaro districts), and one each from the Nile

and Lake Victoria. A remarkable negative feature is the absence, as in Syria, of *Labeo*, a genus abundantly represented in the Nile, Senegal, Niger, Congo, and Zambesi, and India, and more scantily in East and South Africa. It is a suggestive fact, tending to show that, somehow or other, Lake Tsana has only comparatively lately been in communication with the Nile, that the *Varicorhinus* and several of the *Barbus* are common to this lake and to some of the rivers of the eastern watershed; whilst not one of the Cyprinids occurs also in the Nile. The main stream of the Blue Nile has only been explored up to Rosaires, but the fishes obtained in that part of the river do not in any way differ from those of the Upper Nile.

The chief character of the rivers east of the Rift Valley is, as already stated, the number of species of *Barbus*. The Cyprinids are further represented by a few *Labeo* and *Discognathus*, by a *Neobola*, and by the only African representative of the Indo-Malay genus *Rasbora*. The Mormyrids are represented by six species only. The few Characinids belong to the genus *Alestes* and to its near allies *Micralestes* and *Petersius*. Of the twenty Silurids, some are widely distributed species, others are common to the Nile or to the Zambesi, whilst among the species with a restricted habitat we note a *Physailia*, two *Bagrus*, two *Amphilius*, a *Synodontis*, and two *Chiloglanis*—altogether a poor series as compared with other districts of Tropical Africa—and not a single autochtonous genus. A species of the remarkable genus *Kneria*, a few Cyprinodontids, and a few Cichlids of the genus *Tilapia* complete what is for a district of that extent, well watered and within the tropics, a very meagre list.

IV. The Southern Sub-region.

Africa south of the Zambesi system has a poor fresh-water fish-fauna, but this is easily accounted for by the intermittent character of most of its rivers. The list I have drawn up from available data includes only fifty species, seven of which are partly marine. When discussing the distribution of the South African fresh-water fishes eight years ago Professor Max Weber compiled a list of sixty-four species; but this included a number of truly marine forms, occurring only in estuaries, besides a few of very doubtful determination, which I am obliged to leave out. The majority of the exclusively fresh-water fishes are Cyprinids, viz., seventeen *Barbus* and three *Labeo*. Characinids are represented by the widely distributed *Hydrocyon lineatus*, which occurs in the Limpopo, and the newly discovered *Alestes natalensis*, from near Durban. Three *Clarias*, an *Eutropius*, a *Gephyroglanis*, and a *Galeichthys*, the latter semi-marine, represent the Silurids. The two *Galaxias*, as distinguished by Castelnau, the most remarkable type of the South African fish-fauna, and the two *Anabas*, are confined to the south-western district of Cape Colony. A Cyprinodontid of the genus *Fundulus* has been described from False Bay. Four Gobies and five Cichlids of the genera *Hemichromis*, *Paratilapia*, and *Tilapia* complete the list.

Poor as it is in fishes, the south-western district—the *Erica or Protea district* of Max Weber—derives a special character from the presence of the genera *Galaxias* and *Anabas*. The western district is also poor, and has only representatives of three families: Cyprinids, Silurids, and Cichlids; whilst the eastern district, from the Limpopo system and the tributaries of the Orange River to Natal, is the richest, two families, Characinids and Gobiids, being represented in addition to the three above named. The recent discovery in the Vaal River of a *Gephyroglanis*, a Silurid genus otherwise known only from the Congo and Ogowe, deserves notice.

Whether the subterranean reservoirs of the Kalahari are inhabited by fishes, as is the case in the Northern Sahara, is still unknown.

Excepting such forms as are believed to have been directly derived from marine types, there is every reason to regard the piscine inhabitants of the fresh waters of South Africa as comparatively recent immigrants from the North.

V. Madagascar.

It is extremely remarkable that this great island, which in most groups of animals shows so many striking features, should in its fish-fauna be one of the most insignificant districts in the whole world. For, if we exclude the numerous Grey Mullets and Gobies, and a few Perches of the genera *Kuhlia* and *Ambassis*, which live partly in the sea, and probably mostly breed in salt water, the truly fresh-water fish-fauna is reduced to sixteen species—viz., two Silurids, two Cyprinodontids, one Atherinid, four Cichlids, and seven Gobiids, the latter, no doubt, recent immigrants from the sea. The Silurids belong to two distinct genera, *Læmonema*, allied to the African *Chrysichthys*, first discovered in Mauritius, and *Ancharius*, allied to the marine or semi-marine *Arius*, and, perhaps, also entering the sea. Of the four Cichlids two belong to a very distinct autochtonous genus, *Paretroplus*, whilst the two others are respectively referred to the African genera *Tilapia* and *Paratilapia*. The two Cyprinodontids belong to the widely distributed genus *Haplochilus*.

In concluding this sketch, whilst looking back with satisfaction upon the rapid progress which African ichthyology has lately made, and expressing our gratitude to the Governments, institutions, and collectors to whom we owe this progress, we cannot abstain from pointing out how much remains to be done. All the great lakes are insufficiently explored, and Bangwelo has never been fished for scientific purposes, whilst within the limits of this colony an extensive collection from the Upper Zambesi is still a desideratum, and Lake Ngami is drying up without any of its fishes having been secured for study. The fishes of the Congo above Stanley Falls, and of many of its northern and all of its southern tributaries, are still unknown. But it is gratifying to observe the ever-growing interest in this hitherto somewhat neglected branch of zoology, and I may express the hope that the next decade will be productive of even greater results than have been achieved within the last. The privilege which has been conferred upon me of addressing you on this occasion shows the appreciation in which systematic ichthyology is held by the zoologists of the British Association.

The following Paper was read:—

Recent Work on Gametogenesis and its Bearing on Theories of Heredity. *By* L. Doncaster, *M.A.*

Many years ago Weismann put forward the hypothesis that the material bearer of hereditary qualities is the chromatin of the nucleus. Recent work has made it necessary to revise a large part of Weismann's scheme, but has confirmed the central theory, that the chromosomes are the bearers of inherited characters. The most recent work on the maturation of the germ-cells has shown that they contain a mechanism which seems precisely adapted to bring about that segregation of characters which forms the most fundamental part of the Mendelian theory, and it seems hardly possible that the two things are unconnected.

That hereditary qualities are borne by the nucleus of the germ-cell is shown by the fact that the spermatozoon consists of little else, the tail being a motor organ, and the middle piece part of the apparatus for cell-division. Further, Boveri's experiments on the fertilisation of non-nucleated fragments show that when no egg-nucleus is present the inherited qualities of the larva are exclusively paternal.

It is also fairly certain that the chromosomes are the essential part of the nucleus in this connection. When an egg (*e.g.*, of a sea-urchin) develops parthenogenetically only half the normal number of chromosomes are present, and yet the larva is normal. But there is evidence that the chromosomes are qualitatively different from one another, and that when all the necessary kinds are not present in a cell that cell cannot develop further. This is shown by

dispermic eggs, in which a quadripolar spindle may result, and ultimately the egg segments into four cells. Each of these cells may contain more than half the normal number of chromosomes, but they are irregularly distributed, and in one or more cells one of the chromosomes necessary for further development is absent, and the cell remains inactive. All theories of this kind postulate the individuality of the chromosomes. That this hypothesis is true is indicated by their constant number and by the fact that in some species (*e.g.*, *Brachystola*, described by Sutton) they differ from one another in size and shape, and these differences are constant. Further, when for any reason the number becomes abnormal, as when an egg develops parthenogenetically, the abnormal number persists in the later cell-divisions (Boveri, &c.). Moenkhaus found that in two fishes, *Fundulus* and *Menidia*, the chromosomes differed in form, and when the egg of one was fertilised by sperm of the other the two kinds of chromosomes could be recognised in the mitoses of the embryo as long as it continued to develop. We may therefore take the hypothesis of chromosome individuality as probable, if not certain, and proceed to consider its bearings on theories of heredity.

In most of the recent work on gametogenesis it has been established that the spireme thread of the primary spermatocyte splits longitudinally and then segments into half the number of chromosomes characteristic of the species. These chromosomes then split transversely, giving an equal number of tetrads. The two maturation divisions then separate the four quarters of each tetrad into the four daughter-cells which give rise to the gametes. Farmer and Moore have described a slightly different, but exactly equivalent, process in the vertebrates and higher plants, by which the original spireme segments are divided by one transverse and one longitudinal division among the four daughter-cells. It may therefore be assumed that this process is universal in gamete-formation, the differences being only in detail. Montgomery, Gross, and others have found in certain insects and other forms that the spireme of the primary spermatocyte breaks up into the normal number of segments, instead of the half number; these split longitudinally, and then become paired together end to end. In this way a number of tetrads is formed which is half that characteristic of the somatic cells of the species, as in the cases referred to above. This gives us definite evidence that the spireme segments which appear in half the normal number in the more common cases are bivalent, and are equivalent to two chromosomes attached end to end.

It has been found by Gross, Montgomery, and others that in some insects where this pairing of chromosomes takes place they differ from one another in size, and those two which pair together are always alike. In *Brachystola* the chromosomes are of very various sizes and shapes, and in all the cells, from the fertilised egg up to the primary spermatocyte, there are two of each kind. In the primary spermatocyte each pair of similar ones becomes coupled together, and also longitudinally split, and by the two maturation divisions the four quarters of the tetrad so formed are distributed into the four cells which develop into spermatozoa. As this happens with all the tetrads, it is evident that in each spermatid or ovum there is *one* chromosome of each kind, and when the spermatozoon conjugates with the ovum each introduces one of each kind, and so the double number characteristic of the zygote is produced.

From this it appears that of the couples of chromosomes which pair in the primary spermatocyte, one member of each couple is derived from the father, and the other from the mother, and these are separated into different gametes at the reduction division. But since the arrangement of the pairs in the equatorial plate is a matter of chance, any gamete may receive a paternal chromosome from one pair and a maternal from another. For example, if the reduced number be four and the paternal chromosomes be represented by the letters A, B, C, D, the maternal by *a*, *b*, *c*, *d*, then the pairs will be A*a*, B*b*, C*c*, D*d*, and the possible combinations in any gamete will be A, B, C, D, A *b*, C, D, *a*, B, *C*, D, &c., the total number of combinations being sixteen. If now, using the Mendelian terminology, we regard the chromosomes as each bearing an allelomorphic character, exactly the results will follow which are found in Mendelian cases of inheritance. Using

the same letters, A and a will be allelomorphic characters borne by the corresponding chromosomes, as are B, b, C, c, &c. The zygote will contain all eight chromosomes and characters, but during gameto-genesis allelomorphic characters will of necessity become separated into different germ-cells. If in the *peas* originally described by Mendel A represents yellow, a green, and B represents round, b wrinkled, then gametes will be formed consisting of AB, Ab, aB, ab, but A and a, B and b cannot coexist in the same gamete. We have, therefore, in the observed behaviours of the chromosomes a mechanism which seems exactly adapted to bring about a segregation such as is postulated by the Mendelian theory, and it seems incredible that there can be no connection between the two sets of phenomena.

The most obvious objection to the hypothesis here sketched is that the number of chromosomes is much less than the characters which are inherited. It is possible that many characters are borne by a number of chromosomes together, and are not inherited in the Mendelian manner. This would account for the cases of blended inheritance where segregation does not take place.

But cases are known where there are more truly allelomorphic characters than there are chromosomes, and each chromosome must therefore bear more than one such character. If the chromosome is an individual, these characters must always be associated, and cases of correlation of this kind are known. Coupling of characters would, however, be much more frequent if this were the complete explanation, and we must fall back on the hypothesis that the chromosomes are not indivisible units. At first sight this seems to contradict the assumption made above concerning chromosome individuality, but the evidence is equally in favour of the view that chromosomes are definite aggregates of individuals, which become associated together at cell-division. Several cases have been described which point in this direction; *e.g.*, Petrunkewitsch states that there are eight chromosomes in the female pronucleus of the bee and sixty-four in the blastoderm nuclei. In *Ascaris*, according to Boveri, there are two chromosomes in the fertilised egg, and in all the nuclei in the 'germ-track,' but in the somatic nuclei they break up into a large number of small units. It seems possible, therefore, that the chromosomes are aggregates of smaller units, which reappear in the same form at each nuclear division, but not necessarily composed of exactly the same constituents. As an analogy one may compare the chromosomes to boats of various sizes which take a party of people across a river; when the people return (representing another nuclear division) there will be the same number of boats, each containing the same number of people, but it is not necessary that the persons in each boat should be the same as at the first crossing. If this hypothesis is true, it involves the further assumption that if a character Z is transferred from chromosome A to chromosome B, then the allelomorphic character z must at the same time migrate from a to b, for otherwise the pairing and separation of allelomorphs could not be effected. Probably, however, the formation and pairing of chromosomes consists in the association and pairing of homologous units, and one can be imagined as easily as the other. The mosaics which occasionally occur may perhaps be accounted for by the arrangement of homologous units in chromosomes of different pairs.

THURSDAY, AUGUST 17.

The following Papers and Reports were read :—

1. *Cases of Extensive Mortality among Marine Animals on the South African Coast, with Suggestions as to their Cause or Causes.* *By* J. D. F. GILCHRIST, *M.A.*, *Ph.D.*, *B.Sc.*

In the year 1837 great numbers of fish were cast up on the beach at Table Bay. This continued for about three days. Some of the fish were alive. Large numbers of whales were also cast up. In 1880 a still more extensive mortality

among fish occurred. They were thrown up alive on the beach, and their remains a few months afterwards formed a pile five to six feet high.

In December of the year 1886 a similar occurrence took place at Cape Recife, and here, as in the previous cases, the fish were of all sorts, including species of *Dentex, Pagrus, Hoplognathus,* and large sharks. Towards the end of the year 1903 the trawler at Mossel Bay procured in the net quantities of dead fish in an advanced state of decomposition. Dead fish were also seen floating about in the water. In September 1904 many fish were cast up on the beach alive or in a stupefied condition. The sea-temperature observations on this occasion indicated great diversity. On the trawling ground near East London the water was remarkably warm, while at East London the observations were normal, with the sudden drop from 56° to 50° between the 9th and 10th of the month.

Cases of mortality among marine animals in the tidal rivers of the east coast are not infrequent on the occurrence of great floods.

On August 3, just before the meeting of the British Association, an occurrence resembling those above took place near Cape Town, at a place on the west coast of the peninsula near Hout Bay, and is being inquired into.

The author suggested that these occurrences might be due to a peculiar feature of the Cape seas, viz., the great difference in temperature and salinity and contents of the warm Agulhas stream and the Antarctic Drift Current, and expressed a hope that his notes might be of some use in directing attention to this problem and securing additional evidence in connection therewith.

A number of samples of deep-sea deposits found off the South African coast were shown, and attention was drawn to the suggestion that the extensive occurrence of phosphate of lime in these deposits, together with organic remains, such as sharks' teeth, earbones of whales, &c., might be associated causally with such occurrences as those enumerated above.

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2. *Recent Discoveries in the South African Deep Sea.* *By* J. D. F. Gilchrist, *M.A., Ph.D., B.Sc.*

The author gave a demonstration of the more interesting forms in a collection of deep-sea animals shown in the Museum of the South African College, and special attention was devoted to certain questions, such as methods of reproduction of deep-sea fish, the significance of luminous organs, and parasitism. A large viviparous deep-sea fish (*Cataetyx*) and its embryos were shown, as also the eggs of *Macrurus fasciatus,* secured from the ripe female and also by tow-netting at a depth of about 100 fathoms, some of the latter containing embryos. It was shown that the luminous organs were, in the case of a species of *Scopelus,* sexual, and that deep-sea fish were much more liable to be infested with parasitic copepods than shallow-water forms.

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3. *The Ostrich and its Allies.* *By* A. H. Evans, *M.A.*

This paper, being of the nature of a technical introduction to that of the Hon. Arthur Douglass on ostrich farming, was chiefly concerned with the relation of the Ratite to the Carinate birds. The degeneration of birds in general was discussed, as also the loss of the power of flight in the 'Struthious' group. This led naturally to Merrem's division of the class *Aves* into *Ratitæ* and *Carinatæ,* and the slow though sure recognition which his views obtained. The *Ratitæ* are divided into six orders, and the orders into families. These families were discussed in some detail as regards the species they contain, while the range of each species was defined.

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4. *On Ostrich Farming.* *By the* Hon. Arthur Douglass.

This paper dealt with the commencement of ostrich farming in 1867, and its growth up to the present time.—The best climate, and general conditions for the

industry.—Artificial hatching as used in the early days of the industry.—Present methods of rearing the chicks.—The principal diseases of the birds.—The present different methods of farming them.—The improvement of the breed by selection to obtain better feathers.—The growth of the export of feathers and the range of values.—The habits of the birds when sitting.—Whether the innate wildness of the birds is lessened in the offspring of domesticated ostriches.—Prospects of the future development of the industry in South Africa, and of its being successfully developed in other countries.

5. *The Rôle of Mucus in Corals.*
By Professor J. E. Duerden, *Ph.D.*

Under ordinary conditions the outer surface of coral polyps is covered with a thin continuous layer of mucus, in which objects falling upon the polyp become embedded or entangled.

When first exuded the mucus is thin and watery, but later becomes more consistent. From time to time it is broken up into shreds and patches, which are removed from the surface of the disc by the ordinary exhalent currents from the stomodæum, along with any foreign particles embedded.

Nutritive substances and extractives placed upon the polyp increase the amount of mucus exuded, and also result in an opening of the mouth and the institution of an inhalent stomodæal current, by reversing the dominant outward beat of the stomodæal cilia.

The mucus exuded as a result of nutritive stimuli is drawn down the stomodæum by inhalent currents in the form of distinct streams, and carries with it whatever substances, nutritive or non-nutritive, are embedded or entangled in it.

Ingestion in coral polyps is thus purely mechanical, depending upon whatever substances are capable of producing an inward beat of the cilia, the opening of the mouth, and the exudation of mucus. An inhalent current being established, objects are carried into the polypal cavity without regard to their nutritive value, and independently of any peristaltic motion on the part of the stomodæum.

In the ordinary activities of coral polyps inhalent currents may be occasionally instituted independently of any external stimuli, and these carry with them any inert objects resting upon the disc.

Mucus is of much importance in the protection of the polypal surface from foreign objects; it assists in keeping the surface clean, and also in the entanglement and ingestion of prey and food substances.

6. *Report on the Occupation of a Table at the Zoological Station, Naples.*
See Reports, p. 181.

7. *Report on the 'Index Animalium.'*—See Reports, p. 185.

8. *Report on the Influence of Salt and other Solutions on the Development of the Frog.*—See Reports, p. 175.

9. *Interim Report on the Colour Physiology of the Higher Crustacea.*
See Reports, p. 187.

10 *Fifteenth Report on the Zoology of the Sandwich Islands.*
See Reports, p. 186.

11. *Report on the Madreporaria of the Bermuda Islands.*
See Reports, p. 186.

12. *Report on Zoology Organisation.*—See Reports, p. 186.

13. *Interim Report on the Probability of* Ankylostoma *becoming a Permanent Inhabitant of our Coal Mines in the Event of its Introduction.*—See Report, 1904, p. 292.

14. *Report on the Occupation of a Table at the Marine Laboratory, Plymouth.*—See Reports, p. 183.

15. *Interim Report on the Effects of Sera and Antisera on the Development of the Sexual Cells.*

FRIDAY, AUGUST 18.

The following Papers were read:—

1. *The Origin of Mammals. By* R. BROOM, *M.D., D.Sc.*

The author believes that in early Permian times a Cotylosaurian reptile, owing to its frequenting marshy ground, took to walking with its body well supported off the ground. This habit gave rise to the forward direction of the ilium, and to the pubis and ischium being turned backwards, and also to the great development of the precoracoid. No member of this first stage in the mammalian line is at present known, but Pareiasaurus is apparently a considerably modified offshoot from it.

The next stage in the development arose by the marsh animals finding that the new modification of the limbs was specially suitable for progression on land. The new type of land animal was better equipped than the normal reptile, and took to predatory habits and became an active carnivorous animal. These early carnivorous types form the order of Therocephalians, of which about twenty genera are known.

Between the upper Permian and the upper Triassic times the Therocephalians gave rise to the much improved Theriodonts (or Cynodonts). These Theriodonts are almost mammals in every detail of structure. The only essential difference is that the lower jaw has still a small articular element, which hinges on a small quadrate bone.

The change from the Theriodont to the mammal was probably brought about by a slight change of habit necessitating some antero-posterior movement of the jaw. The small quadrate bone became first a plate of bone and then a plate of cartilage—the inter-articular cartilage and the dentary bone took the place of the articular.

Neither the auditory ossicles nor the tympanic have ever, in the author's opinion, had anything to do with the articulation. The mammalian malleus is held to be the reptilian extra-stapedial, and the mammalian incus the supra-stapedial. The connection between Meckel's cartilage and the malleus, which is hyomandibular, is held to be similar to that between the extra-stapedial and the mandibular cartilage in the crocodile. The mammalian tympanic is the homologue of the distinct tympanic bone of Anomodonts and Theriodonts.

The Primitive Diapsidan Reptiles.—The author showed that there are various reasons for believing that in addition to the great radiation of Diapsidan reptiles in Triassic times which gave rise to the Crocodiles, Dinosaurs, Pterodactyles, and

others, there had been an earlier radiation in Permian times which gave rise to many types, most of which have become extinct. These early Permian Diapsidan forms had notochordal vertebræ, plate-like pubis and ischium, and a distinct precoracoid. Procolophon is believed to be a slightly modified descendant of the simplest Permian types. Mesosaurus and Stereosternum are regarded as aquatic modifications, Palæohatteria a slightly specialised semi-aquatic modification, and the Pelycosaurs very highly specialised offshoots of the same early type.

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2. *On some Earlier Stages in the Development of* Peripatus Balfouri. *By* W. F. Purcell, *Ph.D.*

In his well-known paper on the development of the Cape species of *Peripatus*[1] Adam Sedgwick gives a detailed description of the segmentation stages of the ovum of *Peripatus Balfouri*, and he also gives figures of a very complete series of stages, from the unsegmented ovum up to the formation of the solid gastrula.

Now Sedgwick states that his drawings of the segmenting ova were made from fresh specimens, and not merely from ova which had been hardened by chemical reagents, and it may therefore, perhaps, be imagined that a subsequent investigation of the same stages would not materially alter his observations and conclusions.

Some time ago the author collected a considerable amount of *Peripatus Balfouri* material in the Cape Peninsula, and preserved a large number of segmenting ova in the usual fixing fluids, such as picro-sulphuric acid, corrosive sublimate, &c., and a few were also placed in a weak solution of formalin. He stated that the oviducts containing the ova were removed from the animal to the formalin as rapidly as possible, so as to avoid the possibility of the contact with air injuring or altering the ova, which were subsequently examined under the microscope in the same liquid.

These formalin preparations of segmenting ova differed remarkably both from similar ova preserved in other reagents as well as from the ova which have been figured by Sedgwick, and the conclusion come to, after carefully examining a number of preparations, is that these formalin preparations represent the true condition of the segmenting ova, and consequently that the ova examined by Sedgwick, like those preserved in picro-sulphuric acid, &c., had in many cases been more or less strongly altered by external influences, and no longer represented the normal course of the development.

The ovum of *Peripatus Balfouri*, according to Sedgwick, is oval in shape, slightly less than half a millimètre in length, and lies within a transparent, rather thin egg-shell. The greater portion of the ovum consists of a pale, spongy mass with a few scattered refractive bodies. On one side of the egg, midway between the two ends, is a more opaque mass of denser protoplasm, containing the nucleus, and this point is designated the dorsal or animal pole. The ovum first divides into four large cells by transverse and longitudinal vertical cleavages, which, however, are only partial, not completely separating the segments. Then the larger, clearer portion of each of these segments becomes separated from the smaller, more opaque, nucleated portion of protoplasm, and gives rise to the endoderm, while the latter forms the ectoderm. Both continue to divide and subdivide, so that the endoderm comes to consist of a number of large and small branched and anastomosing bodies without visible nuclei, all connected with one another and with the ectoderm by strands of protoplasm; and the whole embryo is therefore a syncytium, the only visible nuclei of which are those contained in the ectoderm.

The author has, unfortunately, none of the very earliest segmentation stages preserved in formalin, the earliest being that in which eight ectodermal cells are present. Viewed in transmitted light such an embryo has the following appearance:—

The eight ectodermal cells, which lie in two longitudinal rows against the

[1] *Quart. Journ. Micr. Sci.*, vol. xxv., 1885.

inner surface of the egg-shell, appear dark and opaque, with a lighter part representing the nuclei, while on the free periphery of each is a transparent, sharply defined portion, in which lie a number of small stainable bodies.

Underneath the ectodermal epithelium are a larger number of large oval or more or less spherical cells, loosely packed in the remaining space within the egg-shell and constituting the endoderm. Each of these cells resembles in structure the peripheral portion of the ectodermal cells, being transparent and provided with a number of small stainable granules, resembling yolk granules. They lie in contact with one another and with the ectoderm, and have clear convex contours, except where two are pressed together, when, of course, their surfaces are more or less flattened. In no case were any anastomosing branches connecting these cells with one another or with the ectodermal cells observed, and the liquid interspaces were perfectly clear.

Now, if such an embryo is compared with a similar stage preserved in picro-sulphuric acid, &c., and subsequently hardened in alcohol, it is seen that while the opaque portions of the ectodermal cells remain the same, their transparent peripheral portions, as well as the whole endodermal mass, become to a great extent disrupted by the bursting of their delicate membranes and the scattering and contraction of their contents, and we get preparations resembling some of those drawn by Sedgwick.

The subsequent development of the embryo takes place as follows:—

All the cells divide and subdivide, and when there are about thirty-two ectodermal cells the endoderm becomes grouped into several masses, the greater part, however, congregating towards the two ends of the egg-shell. At the same time the endoderm contracts greatly in bulk, becoming quite opaque and adhering in two or several masses, or in the form of a ring, to the periphery of the ectodermal epithelium. As the endoderm decreases in bulk the clear liquid in which it lies within the egg-shell increases in the same degree, and ultimately occupies a much larger space than does the whole embryo. Soon afterwards the whole endoderm comes together, forming an apparently solid mass, round which the ectoderm grows like a case. This stage represents, then, the solid gastrula.

Sedgwick correctly observed this aggregation of the endoderm at the final stage, and explains the process by assuming that his branched endodermal cells were amœboid and capable of independent movement, and that they wander towards the periphery of the ectoderm.

The true explanation of the process is as follows:—

When the endoderm begins to aggregate itself into masses the liquid within the endodermal cells passes out, so that the latter contract, their protoplasm becomes denser and firmer, and as the cells were always in contact with one another and with the edges of the ectodermal plate, they simply leave the lower part of the egg-shell and are drawn mechanically towards the edge of the ectoderm.

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3. *Habits and Peculiarities of some South African Ticks.* *By* C. P. Lounsbury, *B.Sc., F.E.S.*—See Reports, p. 282.

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4. *The Buccal Apparatus of a Tick (Hæmaphysalis punctata C. and F.).* *By* George H. F. Nuttall, *F.R.S.*, W. F. Cooper, *B.A.*, *and* R. D. Smedley, *M.B.*

Although the external features of ticks have been repeatedly described, very little work has been done on the internal anatomy, this doubtless owing to the difficulty of demonstrating delicate structures which are enclosed within thick and tough chitinous parts. Although our work has only reached a preliminary stage, we have thought that it would be of interest to present a paper on the subject, especially to a meeting of biologists in South Africa, where ticks are a source of more than usual interest, since the part they play in conveying certain fatal

protozoal diseases to domesticated animals has been fully demonstrated. We reserve a detailed treatment of the subject for a future paper.

A tick is a headless creature whose brain lies within its body. The so-called 'head' is really made up of mouth parts and appendages which protrude from the body anteriorly, the whole being termed the rostrum. The *rostrum* consists of a basal 'ring' of thick chitin, which articulates posteriorly with the 'dorsal shield,' and is continuous laterally and ventrally with the softer and thinner integument of the front of the body. The ring bears two palps, two mandibles, and a hypostome (representing the fused maxillæ of other Arachnida).

The *palps* are tactile organs, are articulated antero-laterally upon the ring, and do not serve as organs for penetrating the skin; in fact, when the tick is fixed upon the skin of the host the palps are turned outwards at right angles to the remaining mouth parts. The boring organs are the mandibles, which lie side by side dorsally, and the hypostome situated ventrally to the preceding.

The *mandibles*, which are homologous with the chelicerae of Arachnida, consist of long tubular first joints; the latter are enveloped in sheaths and pass out from the body through the ring, the chitin of which is continuous with a thick outer mandibular sheath which folds backwards distally. This outer sheath is provided with minute, closely ranged, recurved teeth which give the surface a shagreened appearance dorsally and laterally. The shagreened sheath may be compared to a pair of trousers, the chitin at the 'waist' being continuous with the ring and then dividing to form the two legs, only that the legs cohere along the inner seam, and at the end of the trousers leg the chitin again folds inward and backward, ultimately fusing with the inner sheath, which, so to speak, represents the underclothes. These sheaths obviously permit of considerable antero-posterior movement of the tubular joint of the mandible. The latter ends distally in a second, short-toothed joint presenting a very minute and delicate structure which would require a too lengthy description for this occasion. It consists of a first article, formed basally, like a knuckle, and articulating upon the extremity of the tubular first joint. This article contains a cavity communicating backwardly with the 'tube' and outwardly through a pore in the end of the toothed process, in which it terminates distally. A second article is articulated upon the outer, and a third upon the dorsal surface of the first article; and these, which are also provided with sharp teeth, contain cavities which are continuous with that of the first article. Two sets of muscles which run within the tube move this tooth-complex from side to side; a more powerful external set joins on to a stout tendon running to the outer protuberance of the 'knuckle'; a much weaker set pulls on a more delicate tendon running into the internal protuberance. As was shown by lantern-slides, the sharp recurved teeth, especially of the second article, are turned outward, consequently these serve as organs for penetrating the skin, and, when everted, literally anchor the parasite. It is obvious why the muscles which evert the second article should be more powerful than the internal. Apart from this, the mandible as a whole is retracted by powerful muscles running from the dorsal shield of the tick to the inner end of the tube and its sheath. The firm shagreened double-barrelled sheath gives an additional hold and greater rigidity.

The *hypostome* protrudes forwards like the under-bill of a duck; posteriorly it is continuous with the thick, chitinous ring. Its ventral surface is covered with stout recurved teeth, and on its dorsal surface is a median V-shaped groove. The hypostome is in close contact with the mandibles, and is dragged into the wound formed by the latter. Once it has entered it secures a firm hold by means of its recurved teeth. The hypostome is thickened and expanded at its base, where its external surface fuses with the basal ring, and its internal (dorsal) surface gives rise to the attachments of the upper end of the alimentary canal.

The *buccal cavity*, as we term the commencement of the alimentary canal, is a small shallow space enclosed by chitinous walls. A thickening of the fused sheaths of the mandibles, and a backward prolongation from the base of the hypostome, form respectively the roof and floor of this space, which is completed laterally by thick masses of chitin joining these two parts. A groove, continuous with that on the dorsal surface of the hypostome, runs along the floor of this

space. Continuing along the floor of the mouth, we come to an aperture leading downward and backward into the pumping organ; the greater part of this organ lies ventrally in the ring, although it extends within the body, to end, somewhat abruptly, in the œsophagus.

The *pump* and adjoining œsophagus are lined with chitin. On cross-section the pump is seen to be roughly quadrangular, the top being furrowed longitudinally like a V, the bottom showing the same structure reversed. Powerful muscles attached to the ring and the pump serve to expand its lumen; another set of muscles causes contraction, and in this respect the mechanism of the pump in the tick is more complicated than that of the somewhat similar structure which was described in the mosquitoes by Nuttall and Shipley (1903). (In this insect the chitinous walls are caused to rebound by their elasticity, without the aid of contractor muscles.) At the anterior dorsal surface of the pump there is a thickened portion of chitin, which in cross-section appears triangular with the apex pointing downward; and on either side of this, exceedingly minute chitinous spicules, arranged like a comb, protrude into the lumen; a somewhat analogous structure was described at the posterior end of the pump in mosquitoes by the above-mentioned observers. Returning to the buccal cavity, it is seen to end posteriorly in a blind pouch, which lies dorsally to the pump. On either side of this pouch, between it and the pump, lie the salivary ducts; these run forward for a short distance and open into the pouch, close to where the latter joins the pump, to form the buccal cavity. They possess a structure ('spiral thread') similar to that of tracheæ, and will be considered later in conjunction with the salivary glands. These ducts, two in number, are very delicate and of considerable size; as they approach the buccal cavity, they pass through a thickened chitinous foramen whose function appears to be to keep them patulous. We have failed to detect any pumping structure for the secretion.

We find that previous authors appear to have misunderstood the buccal mechanism; for the few who have attempted to figure it (Heller, Pagenstecher, Macleod) have not represented the structure accurately.

Space and time do not permit us to give a description of other parts of the tick. Hitherto the want of material has hindered us in our work on the well-known pathogenic ticks of South Africa. Therefore, before concluding our paper, we take this opportunity of mentioning to those interested in tick-diseases that their co-operation in collecting material for us will greatly aid this research.

TUESDAY, AUGUST 29.

The following Papers were read:—

1. *Pearl Oysters and Pearls. By* Professor W. A. HERDMAN, *F.R.S.*

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2. *Cephalodiscus.*[1] *By* Dr. S. F. HARMER, *F.R.S.*

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3. *Demonstration of* Ankylostoma *Preparations. By* A. E. SHIPLEY, *F.R.S.*

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[1] Published in *Reports of the Siboga Expedition.*

JOHANNESBURG.

WEDNESDAY, AUGUST 30.

The following Papers were read:—

1. *Mimicry in South African Insects. By* Professor E. B. Poulton, *F.R.S.*

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2. *The Migration of Birds in the Southern Hemisphere.*[1] *By* W. L. Sclater, *M.A.*

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3. *On some South African Land Planarians.* *By* Dr. H. Lyster Jameson.

Some dozen species of Land Planarians have recently been collected in Natal, all of which, with the exception of the cosmopolitan and imported *Placocephalus kewensis*, are new and are provisionally referred to the essentially African genus *Amblyplana*. The lack of anatomical data makes it impossible to accurately define the limits of this genus. These Natal forms, five of which have been studied anatomically, although they approximate externally to *Amblyplana*, and in certain cases to other allied genera, are anatomically very close to the highly specialised *Artiocotylus*. They agree with this genus in the possession of a specialised uterus connected with the fused oviducts by a short stalk. Outside these South African forms this uterus is unknown among Land Planarians, if we except *Rhyncodemus scharffi*, a form described by v. Graff from Ireland, and regarded as doubtfully indigenous.

Von Graff regards this uterus in *Artiocotylus* as homologous with the dorsal outgrowths of the genital atrium found in other forms, and treats its connection with the fused oviducts or 'Drüsengang' as secondary, and the stalk of the uterus as the original connection between the uterus and the atrium.

The discovery of two forms which the author is describing elsewhere as *Amblyplana viridis* and *A. natalensis*, in which the stalk of the uterus is not present and the relations are much the same as in *Rhyncodemus scharffi* among Land Planarians, *Planaria polychroa*, *P. alberscina* and *P. gonocephala* among Paludicola and *Gunda ulvæ* among Maricola, suggests that this diverticulum is really to be compared to the uterus of aquatic forms.

From *Amblyplana viridis* with a simple vagina and 'Drüsengang' giving off the dorsal uterus various modifications can be traced.

The vagina may be provided with a special musculature (as in the species the author is describing as *A. natalensis*), a direct connection (stalk of the uterus) may be developed between the uterus and the genital pore (as in *Artiocotylus speciosus*, v. Graff, and another of the Natal forms), and, finally, the stalk of the uterus may be specialised as a muscular copulating organ, as in two other forms.

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4. *Locust Destruction in the Transvaal, Season* 1904–5. *By* C. B. Simpson.

The subject was treated under the following headings:—

1. *Résumé* of past invasions of the Transvaal. 2. Species of locusts concerned. 3. Life history of locusts: *a*. Brown locusts; *b*. Purple locusts. 4. Paths of migration in the Transvaal. 5. Distribution of locusts in the Transvaal, season 1904–5. 6. Natural enemies. 7. Methods of artificial destruction: Mechanical; Spraying, oils, soap, and arsenical spraying; Locust fungus. 8. Results of locust campaign. 9. Plan for future campaigns.

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[1] To be published in the *Journal of the South African Ornithological Union.*

FRIDAY, SEPTEMBER 1.

The following Papers were read:—

1. *Convergent Evolution, as illustrated by the* Litopterna, *a Group of Fossil Ungulata in Patagonia. By* Professor W. B. Scott.

While Convergent Evolution is admitted by most naturalists to be a frequent and important phenomenon, there is a great difference of opinion as to how nearly identical the results of such a mode of development might be. So far as the *Litopterna* are concerned, there are striking resemblances to certain *Perissodactyls* in teeth, skull, and skeleton, but the differences are many and fundamental. It does not appear at all likely that so complex a structure as a mammalian skeleton was ever produced in identical terms by two independent series.

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2. *A Neuro-syncytial Theory of Development. By* Dr. W. H. Gaskell, *F.R.S.*

The author referred to his theory of the origin of Vertebrates, and pointed out that it was based upon the paramount importance of the central nervous system as the chief factor in the upward progress of the animal kingdom. Every line of investigation pointed to the conclusion that the vertebrate arose from that group of invertebrates which possessed a central nervous system most nearly similar to that of a low vertebrate, such as Ammocotes—an invertebrate, therefore, belonging to the group of Arthropods. This argument had been worked out by the author in a series of papers published in the 'Journal of Anatomy and Physiology,' and receives especial support from the palæontological record. For the dominant race now, the biped mammal man, arcse undoubtedly from the highest race evolved up to that time, the quadrupedal mammals; these in their turn originated from the dominant reptiles, these again from the amphibians, which were the most highly organised group at the time. The amphibians themselves came from the dominant race living in the sea at the time, the fishes; and so, too, according to the author's theory, the fishes arose directly out of the race dominant at the time, *i.e.*, the arthropod group. This theory necessitates the formation of a new alimentary canal at the transition from the arthropod to the vertebrate; a requirement which is no more unlikely than the formation of a new respiratory apparatus at the transition of a fish into an amphibian. The reason why others have found this formation of a new alimentary canal so difficult of acceptance is because embryology, and embryology alone, in its recent teaching makes the alimentary canal, and not the central nervous system, the important organ around which an animal is built up. The author, basing himself especially on Braem's papers in the 'Biologisches Centralblatt,' pointed out that in reality the germinal-layer theory was a physiological and not a morphological conception; that the one criterion of hypoblast was, not its mode of formation, but its ultimate fate, whether or no the definite alimentary canal was formed from it. Morphological laws of development must exist, but, to quote Samassa, 'one thing can be said with certainty at the present time: the germinal-layer theory is not one of them.' The author suggested a reconsideration of the whole matter, and starting with the adult pointed out that the tissues of the body fall naturally into two great groups: those which are connected with the central nervous system—the master tissues of the body—and those which live a free existence without any such connection. The body may be looked upon as composed of a neuro-epithelial syncytium in the meshes of which free cells live. The author then considered the evidence for such a neuro-epithelial syncytium, and showed how a one-layered blastula must result from the coming together ot the neural and epithelial moieties as we pass from the adult to the embryo. He then discussed the nature of the second group of cells, those not connected with the central nervous system, and suggested that they owe their origin to the germ cells. This led to the further suggestion that the Metazoa arose from the Protozoa

by the formation of a mortal neuro-epithelial host, which carried round the immortal germ cells. The differentiation of the host gave rise to the central nervous system and all tissues connected with it. The differentiation of the free living germ cells gave rise to the 'archæocytes,' as Minchin calls them, from which arose the mesenchymatous tissues. This conception of the manner in which the body is built up puts the central nervous system in its right place, as the main factor in the formation of the individual or host from the embryological point of view, just as it is the main factor in the development from the phylogenetic point of view. Finally, as pointed out by the author in his last paper in the 'Journal of Anatomy and Physiology,' vol. xxxix. p. 371, the manner in which the neural canal of the vertebrate is formed is on this theory the necessary consequence of the disuse of the ol dalimentary canal of the arthropod ancestor.

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3. *On the Growing-point in the Vertebrata.* *By* Professor J. Cleland, *M.D., F.R.S.*

It is well known that the medullary folds appear in close connection with the primitive streak or blastopore, and that the parts concerned with the cranium and its contents are the first to appear, while both the mesoblastic somites and spinal nerves appear in succession, each metamere behind that which is immediately proserial to it. It follows, therefore, that it is from the short space between the medullary folds and blastopore that new metameres of the neuro-muscular system are formed, and there is no reason to doubt that the visceral system is extended in the same manner.

The nucleated corpuscles of this region furnish, therefore, the parents of the corpuscles of which the successive metameres of the trunk are composed, and they do so by giving off successive series of corpuscles which belong each to a particular metamere. This is precisely comparable with the early development of Aurelia, in which successive individuals appear each between those previously formed and the main or permanent part of the strobilus. It is just as in Aureliæ, future separate individuals are given off successively from a corpuscular mass, the parent of the whole series.

The only difference between these young Aureliæ and the metameres of a vertebrate is that each becomes in the long run completely free from all the others. This makes it clear that the metamerism of the vertebrata, and indeed all metamerism, is of the nature of incomplete reproduction. In the head the metamerism is less complete than in the trunk, but the growth of successive parts is distinctly in the face proserial—that is to say, from behind forwards to the extremity of the nose and intermaxillary region. Thus the axial structure of the vertebrate animal takes place in two directions from a starting-point at the back of the head; and it may not be amiss to recollect that the vital node of Fleurens is situate in the neighbourhood of this starting-point, and also that in the higher divisions of the vegetable kingdom we have, in like manner, the plumule and radicle taking opposite directions from a common starting-point.

SECTION E.—GEOGRAPHY.

PRESIDENT OF THE SECTION—REAR-ADMIRAL SIR W. J. L. WHARTON, K.C.B., F.R.S.

CAPE TOWN.

WEDNESDAY, AUGUST 16.

The President delivered the following Address:—

IT is sometimes denied to Geography that she has any right to consider herself as a science, the objection being apparently founded on the view that it is a subject that can be learnt by heart, but not studied on any systematic line or reduced to principles which enable advance to be made, as in the more exact sciences, by continual investigation by means of laws discovered in the course of such investigation. This, it appears to me, is a misapprehension due to an incomplete recognition of what Science is, and of what Geography is.

Science is, in its simplest interpretation, 'knowledge,' such knowledge as comes from an intimate acquaintance with and study of any subject duly co-ordinated and arranged. The subjects which the advancing education and civilisation of the world have caused to be minutely studied are very many, and as knowledge has increased specialisation has become a necessity, until the list of sciences is very long.

Science may be broadly divided into several categories.

Pure or Exact Science, such as Mathematics; Natural or Physical Science, which rests on observations of Nature; Moral Science, which treats of all mental phenomena.

Some Sciences are of ancient foundation, some have arisen from new inquiries and needs of man, or from fissure in subjects too wide for convenient treatment as one.

Many of them are capable of exact definition, and their boundaries and limits can be well marked.

To others no very distinct limitations can be assigned. From their nature they overlap and are overlapped by other subjects, and it is impracticable to confine them by a strict line.

Geography is one of the latter.

Geography is one of the most ancient subjects studied with a view of co-ordinating facts. A desire for exact knowledge of, first, the bearings and distances of one place from another for the purposes of intercommunication must have arisen as soon as men became collected into groups whose growing civilisation and needs required travel to obtain what could not be obtained in the community. This was the earliest form of Geography, and it is an aspect which still remains, and to some is, in the modern shape of maps, the principal, if not the sole, end of Geography.

From the earliest times, however, geographical information included other than topographical data.

It was soon found that for the traveller and statesman, whether in peace or war, more was wanted to enable Geography to supply requirements.

The nature of a country, the supply of food and water, the character of the rivers, the manners and customs of the inhabitants, their language and affinities, the climate, and other matters, were all of much moment, and Geography dealt with them all, being, as its name denotes, in the broadest sense a 'description of the earth.'

After the first crude guesses of relative positions, founded on times occupied on journeys, other knowledge was enlisted in the cause.

Astronomy was soon recognised as the only means by which to ascertain the distances of places far apart and separated by seas, but for many centuries this could only be applied to latitude. Still the scientific geographer had to study and use the astronomical and geodetic methods known.

As knowledge increased, the subjects became too wide to be strictly considered as one study, and many have become the objects of special research under different titles.

Geodesy deals with the precise form of the earth and its dimensions.

Geology studies the nature of the materials forming the earth's crust, and the changes in it in past ages.

Ethnology and *Anthropology* treat of the different races of mankind.

The study of *Economics* takes note of the conditions of communities and nations, their laws and systems of government.

Botany and *Zoology* now concern themselves with the details of vegetable and animal life.

Archæology investigates the remains of past civilisations which cover the earth.

Meteorology strives to unravel and reduce to law the complicated conditions of the atmosphere, its continual movements, and the results which have such varying effect on our daily life.

Oceanography, the study of the phenomena of the sea as distinct from the dry land, is still regarded as an integral part of Geography, but is rapidly becoming a subject by itself.

Of all these subjects Geography may be considered to be the parent; and though the family be large and has gone off on many separate lines, it is necessary when taking a large and comprehensive view of the united results of knowledge thus gained, especially from the point of view of Distribution, to return to that parent and consider them on a general or geographical basis.

I cannot pretend to define Geographical Science in a clearer or shorter form than that in which it has been already put by General Sir Richard Strachey, and I will quote his words :—

'To investigate and delineate the various features of the earth, to study the distribution of land and sea, and their effects upon climate, the configuration and relief of the surface, positions on the globe, and so forth, facts which determine the existent conditions of various parts of the earth, or which indicate former conditions, and to ascertain the relations that exist between those features and all that is observed on the earth.'

Strabo, in the opening words of his introduction to his great Geography, puts it thus :—

'If the scientific investigation of any subject be the proper avocation of the philosopher, Geography, the science of which we propose to treat, is certainly entitled to a high place. In addition to its vast importance in regard to social life and the art of government, Geography unfolds to us the celestial phenomena, acquaints us with the occupants of the land and ocean, and the vegetation, fruits, and peculiarities of the various quarters of the earth.'

This was written when Geography included all natural science, and before it

gave birth to so many separate subjects; but it sets forth so admirably the aims which the geographer still pursues that it is worthy of remembrance.

It is not advocated, nor is it in any way necessary, that all should study Geography in the extended sense thus indicated; but it cannot be too strongly pointed out that an educated man—and education is now essential to the successful conduct of affairs—must have a considerable knowledge of the elementary facts of Geography.

These elementary facts are, it is true, of the nature of a lesson, and must be learnt, so to speak, by heart by the aid of maps and books; but this is nothing more than making use of the labours of others without which no advance is possible in any subject, and is common to all studies.

We must, in fact, distinguish between the science of Geography, which consists in ascertaining and co-ordinating new facts, and putting them into a shape for the use of others, which is the work of comparatively few; and the practical Geography which consists of making use of that work, and which, as in many other branches of science, is within the reach of all who choose to devote time to it.

It is the object and business of the British Association to try to interest their fellow-countrymen in all branches of knowledge, to gain if possible more workers in science, but at any rate to induce all educated persons to take advantage of the solid work done by others towards the elucidation of the details of the glorious Nature which surrounds us on all sides, and in so many forms, and without which ignorance and superstition, those primary bars to the advancement of mankind, can never be banished.

It is impossible to have a clear comprehension of history, whether past or current, without calling in the aid of Geography; but unfortunately much history has been written and taught without such aid.

To read the daily paper requires either geographical knowledge or constant reference to maps; and if readers would only make a practice of such reference on every occasion when they are at fault, they would soon find themselves acquiring knowledge of the greatest use to them in the easiest and most interesting manner, and with the smallest expenditure of time.

The mistakes made even by those responsible for the conduct of public affairs, by reason of the want of this essential but elementary knowledge, are innumerable, and to this day there are many who consider themselves highly educated and capable men who cannot even rightly understand a map.

As I have before indicated, good maps are the foundation of all sound geographical knowledge, and these maps must be founded on good surveys.

Now a good survey is a comparatively modern operation, and the parts of the world that have been subjected to it are small indeed.

It is true that we now have general maps of the larger parts of the world, which more or less convey a fair representation of the configuration of land and sea when large areas are considered, but details are sadly lacking almost everywhere.

It is not astonishing, for to make the necessary surveys requires an enormous expenditure of both time and money, and the latter is hard to get until the necessity for its expenditure is patent to the smallest intelligence. Thus many countries long settled and in a high state of civilisation are still without any organised system of survey or maps, and even in the United Kingdom it is only from the year 1784 that a proper survey was established of the British Isles, though no maps were published from it until 1801; and it has proceeded so slowly that it has only recently been in one sense completed, while its revision, badly wanted on account of changes, is still in active prosecution, and must be continued *ad infinitum*.

Such indifference is, however, giving way to experience of the results of absence of proper maps, and all who wish well to the progress of South Africa must be pleased at finding that their provision has been taken in hand on such an admirably scientific basis as is provided by the Trigonometrical Survey, now far advanced, and the successful progress of which is, I believe, greatly due to the inexhaustible energy of my friend Sir David Gill, who seems to find time to

promote and aid all branches of knowledge, and that steps are now being taken to prosecute the detailed topographical survey and provide good maps.

To many people one map is as good as another. They do not pause to consider on what it is based, or what degree of accuracy it probably possesses, but so long as there is a map they are satisfied.

A vast number of existing maps are compiled from the roughest materials: in partly occupied countries, from drawings of small areas placed together as can best be done, by means of places here and there whose relative positions are fairly known by distances along roads, with perhaps in some cases angles and astronomical positions; in less civilised parts by routes of travellers laid down by estimation of the distance traversed and direction of march, checked perhaps by a few astronomical observations of more or less value as the traveller possesses or does not possess the necessary skill.

The compilers of such a map have a difficult task. Discrepancies are, of course, multitudinous. Nothing agrees, and one has to accept, reject, and adjust as best he can on his own responsibility and with what knowledge he can procure of the respective reliability of each author.

Happy is he if he has even a few positions in his map which have been properly determined, as between them he is saved from the constantly increasing errors of adding one little area to another, which if carried on indefinitely culminates in great errors.

Of course such maps are of no practical use, save as giving a very general idea of a country, and when required by the administrator or traveller lead to endless mistakes and annoyances.

The feature of our globe which is now, broadly speaking, most accurately laid down is the coast-line. The safety of navigation has caused general marine surveys to be carried on all over the world during the nineteenth century, which have finally determined the position and shape of the boundaries of the sea.

These surveys, executed for the most part by skilled naval officers with proper instrumental outfit, and supplied especially with reliable chronometers, and based upon frequent carefully determined astronomical positions, have resulted in this boundary line being delineated with an accuracy, so far as its absolute position is concerned, far in advance of any other main feature in maps.

Here I may perhaps explain to those unversed in these matters why this is so.

The position of any spot on the earth's surface can be ascertained in two ways: either by careful measurement by means of an accurate system of triangles from another spot already fixed, or by independent observations of the heavenly bodies and calculations from them, which give the precise latitude and longitude of the place. The former is suitable for positions inland, but entails much time and labour, and is only adopted when a perfect map is to be made, for which it is the indispensable foundation. The latter can be carried on from a ship, and under most circumstances only from a ship, because of the limitations of the methods of determinating longitudes.

Longitude can now be satisfactorily and rapidly ascertained in two ways: by the electric telegraph or by use of chronometers.

The places served by the electric telegraph are still few, and its use is therefore restricted; but the chronometer has been in working use for over a hundred years.

This instrument, which is merely a watch of especial construction, will only keep a steady rate when it is undisturbed by irregular shocks or motions.

No means have yet been found for transporting a chronometer on land without upsetting its regularity, and therefore rendering it useless; but on board a ship it can be so suspended and stowed as to prevent its being disturbed by any ordinary movements of or in the ship. The accurate time of any place departed from, ascertained by astronomical observations, can therefore be carried about on board ship for considerable periods, and by comparison with the local time, also determined by sextant observations of the heavenly bodies, at any required spot on the coast, the difference of longitude is at once obtained with very small limits of

error when a number of chronometers are employed. These two simple yet marvellous instruments, the sextant and the chronometer, have thus placed in the hands of sailors ready means of fixing with great exactitude and celerity the position of selected points on coasts all over the world; and it will be seen that, while the detail of the line of coast between such fixed positions will depend upon the degree of accuracy of the survey or sketch, the general line cannot get far out, as it is constantly checked at the selected points.

It is not claiming too much to say that at the present time very few salient points on the coast-lines of the world are as much as two miles in doubt.

It should be a source of great satisfaction to the Briton to know that both these instruments were devised by Englishmen, John Hadley producing the sextant in 1730, in the form still used, on the basis of ideas formulated by Newton fifty years before; and John Harrison the chronometer in 1736. The latter instrument has undergone modifications in detail, but the principle remains the same. Seventy years elapsed before its value was fully recognised and it came into general use.

It is a still further satisfaction to think that it is British naval officers who have made by far the greatest use of them in mapping the coasts of the whole world. Since the time of the great Captain Cook, British surveying vessels have been constantly employed in this work, not only in British colonies, but in all parts, aiding and often paving the way for British commerce, and for the men-of-war that protect it.

It is difficult to find coasts of any extent that have not been laid down by British marine surveyors. The whole of Africa has been their work. By far the greater part of America, all the south and east coasts of Asia, Australia, and most of the innumerable islands in all oceans have been fixed and laid down by them. Even in the Mediterranean, till very lately, the charts were mostly founded on British surveys, and the improvements now being carried out by other nations on their own coasts in details required for modern navigation do not materially modify the main shapes and positions formerly determined by the British.

It has been, and is, a great work, and I hope I may be pardoned for dwelling on it with pride as the result of the wise administration of the Admiralty for many years, and of the immediate labours of my predecessors as Hydrographer, and as a very great contribution to geographical knowledge, more especially as I do not think that it is generally realised that this great advance in geographic accuracy is due to marine surveyors.

To give an idea of the comparative accuracy of the chronometer method, I may mention that on taking at hazard eleven places distributed all over the world at great distances from England, whose longitudes have been recently determined by means of the electric telegraph and elaborate series of observations, I find that the average difference between the chronometer and the telegraph positions is 700 yards. The shapes of the different continents and the positions of islands as at present on our maps and charts will never be altered except in insignificant degree, and the framework is ready for many years' work of land mapping.

It is not to be inferred from what I say that marine surveys are approaching their close. It is far otherwise. The time given to these enormous extents of coasts and seas, and the necessarily small scales on which the surveys have been carried on, have caused them to be very imperfect in all details. Hundreds of rocks and shoals, both stretching from the land and isolated in the sea, have been missed, and loss of ships and life on these unknown dangers still continues. With the increase of shipping, increased number of ships of heavy draught, the closeness of navigation due to steam, and the desire to make quick passages, smaller inaccuracies of the charts become yearly of greater importance.

As an illustration of the condition of affairs I may mention that in Hamoaze, the inner harbour of Plymouth, one of the headquarters of the British fleet for over 300 years, a small but dangerous pinnacle of rock was only discovered five years ago; whilst numerous other dangers of a similar character have been yearly revealed in close surveys of other harbours in the United Kingdom, supposed to be well examined and charted in the last century.

There never was a greater need for close marine surveys of places frequented by ships than now.

It is interesting to look back and see the gradual progress of the delineation ot the world and to mark how very recent any approach to accuracy is.

The very earliest maps of any extent of country are unfortunately lost to us. The first man who made a map of which any historical record exists is Anaximander of Miletus, about 600 B.C., but we know nothing of it. A map is mentioned by Herodotus as having been taken in 500 B.C. by Aristagoras of Miletus in the shape of an engraved bronze plate whereon the whole circuit of the earth was engraved, with all its seas and rivers, to influence Cleomenes, King of Sparta, to aid the Ionians against Persia. This was probably the work of Hecatæus, to whom early Geography owed much. His works are also only known to us by quotation; but they are especially interesting as containing an early idea of the limits of Africa, which he represents as entirely surrounded by the sea—a circumstance apparently either forgotten or disbelieved in later years.

Erotosthenes, 250 B.C., and Hipparchus, 150 B.C., made great advances, and the former made the first attempt to measure the size of the earth by the difference of latitudes between Assouan and Alexandria in Egypt, an attempt which, considering the great imperfection of his means, was remarkably successful, as, assuming that we are right in the length of the stadium he used, he made the circumference of the globe 25,000 geographical miles, whereas it should be 21,600.

He also devised the system of meridians and parallels as we now have them; but the terms 'latitude' and 'longitude,' to denote positions on those circles, were introduced by Ptolemy.

The maps of Ptolemy, the great Alexandrian astronomer and geographer of A.D. 150, are the earliest we possess. He drew, besides a general map of the whole known world from the southern part of the Baltic to the Gulf of Guinea, north and south, and from the Canary Islands to the China Sea, east and west, a series of twenty-six maps of the different parts.

Ptolemy's maps and his method of representing the spherical globe on a flat surface had a great influence on Geography for many years. After his time the Greek civilisation waned, and the general decline of the Roman Empire, followed by its disruption by the invasion of barbarians, closed the course of discovery in all branches of research for centuries. It is not too much to say that for 1,300 years no advance was made, and until the commencement of exploration by sea, which accompanied the general revival of learning in the fifteenth century, Ptolemy's maps represented the knowledge of the world.

As might be expected, the further he got from the Mediterranean, the greater were his errors; and his representations of Eastern Asia and North-Western Europe are somewhat grotesque, though quite recognisable in the main.

Of Africa south of the Equator he knows nothing, and his map of it terminates with the border.

This is somewhat remarkable, as I am one of those who firmly believe in the circumnavigation of Africa by the Phœnicians sent by Necho, King of Egypt, in 600 B.C. from the head of the Red Sea. As described by Herodotus, the voyage has all the impress of veracity. My personal faith in Herodotus was much strengthened by finding when I surveyed the Dardanelles in 1872 that his dimensions of that strait were nearer the truth than those of other and later authorities, even down to the time at which I was at work, as well as by other geographical tests I was able to apply. When, therefore, he records that the Phœnicians declared that in their voyage they had the sun on their right hand, and says he does not believe it, he registers an item of information which goes far to prove the story correct. Influenced by Hecatæus, who though surrounding Africa by the sea cut it far short of the Equator, Herodotus could not conceive that the travellers had passed to the south of the sun when it was in the southern tropic.

No historical incident has been more discussed than this voyage, commentators varying much in their opinions of its truth. But we have to-day some new facts. No one who has followed the exploration of the ancient buildings in Rhodesia, and considered the information we possess on the early inhabitants of Southern

Arabia, whether we call them Sabæans or Himyarites, can doubt that the former were mainly the work of men coming from Arabia at a very early date, while the period of time necessary to carry out gold-mining operations over the large areas now found to have been exploited must have been very great.

It seems strange that no record of the constant voyages to this El Dorado should remain, but the very natural desire to keep lucrative information to themselves is not an unknown thing amongst traders of the present day, while the conditions of society and the absence of written records of South Arabia would make concealment easy.

The Phœnicians, an allied race, and the great seafaring trading nation of the Mediterranean, succeeded in keeping the majority of their marts secret, and we have incidents recorded showing their determination not to allow others to follow their steps, while to this day we are very doubtful of the limits of their voyages.

It may be considered certain that while we naturally quote Greek historians and geographers as the early authorities for the growth of geographical knowledge, and that the scientific basis for proper maps of large areas was really provided by them, the seafaring nations, Arabians, Phœnicians, and Chinese, knew a very great deal practically of the coasts of various parts of the Old World that were absolutely unknown to the Greeks.

The favourable conditions afforded by those remarkable periodic winds, the monsoons, would in the China Sea, Bay of Bengal, and the Arabian Sea naturally facilitate any attempts at extensive sea voyages, and would lead to such attempts under conditions that in the regions of variable winds would be considered too dangerous and uncertain. The fact that the monsoons in nearly every case blow practically parallel to the coasts in opposite directions is a most important factor in considering early navigation. The direction of the wind itself in such cases roughly guides a vessel without a compass, and the periods of cyclones and unsettled weather between the monsoons would soon be noted and avoided, as they are to this day by the Arabs and Chinese, whose vessels, I have very little doubt, have remained practically the same for thousands of years.

The unknown Greek author of that unique and most interesting document, the 'Periplus of the Erythræan Sea,' probably of the first century A.D., describes vessels built without nails, whose planks were bound together by cords, in precisely the same way as many Arab dhows now navigating the Indian Ocean. His personal knowledge of Africa evidently ceased at Cape Guardafui, though he gives information gained from others on the East Coast as far as Zanzibar, which —or, rather, a part on the mainland near—he describes as the limit of trade to the south. We know that Arabs had penetrated further, but no doubt they kept their knowledge to themselves.

These early navigators very probably had charts. When Vasco da Gama first passed along the eastern coast of Africa he found that the Arab dhows had charts. Unfortunately none of them has come down to us, or it would have been interesting to compare them with those of the West Coast used by the Portuguese at the time, and which were of the crudest description.

I claim for sailors of all ages that they would be the first to make practical maps of the shape of the coasts. Their safety and convenience demanded it, while it is a far easier task to compile such a picture of the earth from successive voyages along coasts over the sea, where average distances from known rates of sailing and courses from the sun and stars can be more accurately ascertained than from long and generally tortuous land journeys in directions governed by natural features, towns, and so forth. A navigator *must* be a bit of an astronomer. A landsman to this day seldom knows one star from another.

It was the sea-charts, or *portolani*, of the Middle Ages that on the revival of learning first gave respectable representations of the shape of the coasts, at a time when the learned monks and others were drawing the most fantastic and absurd pictures which they called maps.

At the same time it must be remembered that in all ages and down to the present day pilots, who within a hundred years were usually carried by all ships, even for sea voyages, jealously keep their knowledge largely in their heads, and

look upon good charts as contrivances to destroy their profession, and that such charts or notes as they had they would keep religiously to their fraternity.

The Egyptians were no sailors, but we know that they habitually employed Phœnicians for sea expeditions, while we have the historical record of the Old Testament for their employment by David and Solomon for a like purpose in the Red Sea, and probably far to the south. It is, therefore, almost impossible to doubt that the Phœnicians were also acquainted with the navigation of the Red Sea and east coast of Africa. Such a voyage as that recorded by Herodotus would under these circumstances be far from improbable.

The varying monsoons which had led the Arabians centuries before to get so intimate a knowledge of the east coast as to enable them to find and work the gold-fields would be well known to the Phœnicians, and the hardy seamen who braved the tempestuous regions lying between Cadiz and Great Britain would make little of the difficulties of the African seas.

The limit of easy navigation from and to the Red Sea is Sofala. I do not think that it is too great a use of imagination to suppose that it would be from information received in what is now North Rhodesia that it was learnt that to the westward lay the sea again, and that this led to the attempt to reach it by the south.

Once started from the neighbourhood of Sofala, they would find themselves in that great oceanic stream, the Agulhas Current, which would carry them rapidly to the southern extremity of Africa.

I, as a sailor, can also even conceive that finding themselves in that strong current they would be alarmed and attempt to turn back, and that after struggling in vain against it they would have accepted the inevitable and gone with it, and that without the Agulhas Current no such complete voyage of circumnavigation would have been made.

As Major Rennell in the last century pointed out, once past the Cape of Good Hope, the periodic winds, and over a great part of their journey the currents, would help them up the West African coast; and the general conditions of navigation are favourable the whole way to the Straits of Gibraltar, the ships keeping, as they would do, near the land; but we can well understand that, as recorded, the voyage occupied nearly three years, and that they halted from time to time to sow and reap crops. I should say that it is highly probable that either Simon's Bay or Table Bay was selected as one of these stopping-places.

No reference to this voyage has been found amongst the hieroglyphic records, and, indeed, so far few such records of Necho, whose reign was not for long, are known; but that it was regarded at the time as historical is evident, for Xerxes, a hundred years later, sent an expedition to repeat it in the contrary direction.

This, however, failed, and the unfortunate leader, Sataspes, was impaled on his unsuccessful return.

This attempt shows that the greater difficulty of the circumnavigation from west to east, as compared with that from east to west, was not realised, and points to the concealment of any details of the successful voyage.

Of Hanno's voyage from the Straits of Gibraltar to about Sierra Leone, the date of which is uncertain, but from 500 to 600 B.C., we should know little had not good fortune preserved the record deposited in a Carthaginian temple.

But the well-known secrecy of the Phœnicians in all matters connected with their foreign trade and voyages would explain why so little was known of Necho's voyage, and our present knowledge of the extensive ancient gold workings of Rhodesia shows how much went on in those times of which we are wholly ignorant.

I have dwelt perhaps too long on this subject, but it has to me a great interest; and as it has not, so far as I know, been dealt with by a seaman who is personally well acquainted with the ways of seamen in sailing ships and with the navigation of the coasts in question, I hope I may be excused for putting my views on record.

There are several references in Greek and Latin historians to other circumnavigations, but none of them can be trusted, and apart from Necho's voyage we hear nothing of the east and south coasts of Africa until the arrival of the Portu-

guese at the end of the fifteenth century. But they found a thriving civilisation along the coast from Sofala northward, Shirazi, Arab, and Indian.

Ruins exist in many places which have not yet been properly investigated, and we are quite unable to say from what date we are to place the earliest foreign settlements, nor how many breaks existed in the continuity of the gold-mining, which apparently was proceeding at or very shortly before the Portuguese visit.

After the recommencement of exploration by sea in the fifteenth century, seamen slowly gathered enough information to draw the lines of the coasts they passed along, and in time—that is, by the middle of the eighteenth century—most lands were shown with approximately their right shapes. But of true accuracy there was none, for the reason I have before mentioned, that there was no exact method of obtaining longitude.

If we look at a general world chart of A D. 1755—and to get the best of that period we must consult a French chart—we shall find on this small scale that the shape of the continents is fairly representative of the truth. But when we examine details we soon see how crude it all is.

I have compared with their true positions the positions of thirty-one of what may be taken as the fundamental points in the world as given in the larger scaled French charts of 1755, from which the general one is drawn, and I find that on an average they are forty-eight miles in error. The errors vary from 160 miles to two miles. If the delineation of the coast-lines between be considered the inaccuracies are very much greater.

Very shortly after this date more accurate determinations began to be made. The method of lunar distances was perfected and facilitated by tables published in the various astronomical 'ephemerides,' and seamen and explorers commenced to make use of it. Still the observation required constant practice, and the calculation, unless constantly made, was laborious, and it was used with complete success by the few. The great Captain Cook, who may be looked upon as the father of modern methods of surveying, did much to show the value of this method; but the chronometer came into use shortly after, and the principal advance in exact mapping was made by its aid, as I have already stated.

There is a vast amount yet to be done for Geography. Until we possess publications to which we can turn for full information on all geographical aspects of things on this globe of ours, there is work to be done. Seeing that our present publications are only now beginning to be worthy of being considered trustworthy for the very small amount of knowledge that we already possess, geographical work in all its branches is practically never-ending.

But of exploration pure and simple very little remains to be done. The charm of travelling through and describing an entirely new country which may be practically serviceable to civilised man has been taken from us by our predecessors, though limited regions still remain in Central Asia and South America of which we know little in detail.

I must except the Polar regions, which are in a somewhat special category, as their opening-up affords few attractions to many people. But a knowledge of the past history of our globe—fit study for human thought—can only be gained by study of the portions still under glacial conditions.

What is there round the South Pole—a continent or a group of large islands? What is going on there? What thickness does ice obtain? Have these regions always been glaciated; and if not, why not? Can we get any nearer the mystery of magnetism and its constant changes by study at or near the magnetic poles? All these and many other scientific questions can only be solved by general geographical research in these regions, and all interested in such questions have been delighted at the recent attempts to gain more knowledge.

The object of these expeditions was frankly and purely scientific. All hope of remunerative whale or seal fisheries had been dispelled by the visit of the Norwegian whalers in 1892 to the region south of Cape Horn, and the known general condition of the land forbade any expectation of other profitable industries, unless indeed gold and other valuable minerals should be found, which is always

possible. Beyond the fact that exploring expeditions of this character keep alive the spirit of enterprise and bring out the finest characteristics of a race—which is a point by no means to be despised—no immediate practical benefit was to be expected.

Progress under the conditions must be slow, but I think that Great Britain may well be satisfied with the information collected in the Antarctic by Captain R. F. Scott and his gallant companions. The unfortunate detention of the 'Discovery' by an unfavourable summer prevented the further coastal exploration which was part of the programme, but gave opportunity for further detailed examination of the inland conditions, which was carried out in defiance of the severest atmospheric and topographical difficulties, and with the greatest zeal and intelligence; and it may be doubted whether Science in the end has not gained more than she lost by the unexpected diversion of energy. The healthy conditions which prevailed throughout are a standing proof both of Captain Scott's eminent capacity as a leader and of the cheery spirit which animated the whole expedition.

The full results of the scientific observations are not yet worked out, and in many cases for a complete appreciation of their bearing they must be compared and correlated with those of the other Antarctic expeditions, but many highly suggestive points have already been revealed.

For the first time Antarctic continental land has been travelled over for long distances, and though the actual area of new discovery looks small on a map of the world, the distances covered can only be described as extraordinary, and far exceeding the most sanguine anticipations.

Few who considered the mountainous coast-line of Victoria Land and its complete glaciation, as reported by Sir James Ross from his distant view, thought that it would prove practicable not only to ascend those mountains, but to reach to heights much surpassing them behind.

The reason that it proved feasible is that, while there are occasional heavy snowstorms, the annual snowfall is small, and the surface, therefore, is generally unencumbered with soft deep snow.

And what did Captain Scott find after his memorable struggle up the glacier through the mountains?

An enormous plateau at an elevation of about 9,000 feet, nearly level, smooth, and featureless, over which he travelled directly inland for over 200 miles, seeing no sign at his furthest point of any termination or alteration in character. So far as could be seen from other journeys, glacial discharge from this great ice-sheet is very small, and practically it appears to be dead. Its accretion by fresh snowfall is insignificant, while on all sides along the flanks of the coastal mountains there are signs of diminution in the mass of ice.

The great ice-barrier east of Ross Island tells the same tale. This magnificent feature presents to the sea a face of perpendicular ice-cliffs varying from 60 to 240 feet in height and 450 sea-miles long. Sir J. Ross mapped its position in 1841, and Captain Scott finds that it has retreated on an average fifteen miles, varying much in different parts.

Should this rate of retreat continue the whole of this ice mass, as far as Captain Scott saw it, will have vanished in 1,000 years.

As the motion of the ice mass is also about fifteen miles to the north in the same time, icebergs covering collectively an area of 450 miles by 30 have been discharged from it in sixty years.

Captain Scott travelled over it nearly due south to a point 300 miles from its face, and then saw no sign of its end.

It is bordered on its western side by a mountainous coast-line, rising in places to 15,000 feet. He found the ice practically flat and wholly unfissured, except at the side, where its northerly motion, found to be about 130 feet in the month, caused shearing and vast crevasses. All that is known of its eastern edge is that it is bordered, where it meets the sea, by land from 2,000 to 3,000 feet high, suspected by Ross and verified by Captain Scott. This may be an island, or more probably the eastern side of the great fiord or bay now filled by the barrier.

Captain Scott is of opinion that this great ice-sheet is afloat throughout, and I entirely agree with this conclusion. It is unexpected, but everything points to it.

From soundings obtained along the face it undoubtedly has about 600 feet of water under it. .

It is difficult to believe that this enormous weight of ice, 450 miles by at least 360, and perhaps very much more, with no fall to help it along by gravity, can have behind it a sufficient force in true land glacier to overcome the stupendous friction and put it in motion if it be resting on the bottom. It is sufficiently astonishing that there is force enough even to overcome the cohesion at the side, which must be very great.

The flat nature of the bottom of the Ross Sea and the analogies of many geographical details in other parts of the world make it most probable that the water under the whole barrier is deep.

A point on which I have seen no comment is the difference in the appearance of the slopes of Mount Terror. Captain Scott found the bare land showing over large areas, but during the two summers of Ross's visit it was wholly snow-clad. Sir Joseph Hooker, the sole survivor of Ross's expedition, when questioned had no doubt on the subject, and produced many sketches in support.

This may be due to temporary causes, but all the information collected by the expedition points without doubt to steadily diminishing glaciation in recent times. We have, therefore, this interesting fact, that both in Arctic and Antarctic regions, as indeed all over the world, ice conditions are simultaneously ameliorating, and theories of alternate northern and southern maximum glaciations seem so far disproved.

But this does not mean that climatic conditions in the Antarctic are now less severe—probably the contrary. It has been pointed out by many that land glaciation may arise from varied primary causes, but one obvious necessity is that the snowfall should exceed melting and evaporation. It need not be heavy; but if it is, it may produce glaciation under somewhat unexpected conditions. This would entail a vapour-laden air more or less continuously impinging upon the land at a temperature which will enable it when cooled, either by passing over chilled land or when raised to higher regions by the interposition of mountains, to give up its moisture freely. This condition is not fulfilled when the air as it arrives from the sea is already at a very low temperature.

It was my fortune to spend two long seasons in the Straits of Magellan, and I was daily more impressed by what I saw.

There you have a mountainous ridge of no great height—very few peaks rising more than 4,000 feet—opposed to the almost continuous westerly winds pouring in from the Pacific at a very moderate temperature and charged with much moisture.

The result is that in the latitude of Yorkshire every mountain mass over 3,000 feet high is covered with eternal snow, and sends glaciers down to the sea.

I was convinced by what was going on under my eyes that it only required an upheaval of the land of 2,000 feet or so to cover the whole of Patagonia with ice. But then the climate would still not be very severe. The temperature of the wind from the sea would be the same, and such part of it as blew along the channels and on the lower land would moderate the cold caused by the ice-covered slopes.

The shores of the whole of Western Southern Patagonia, deeply indented with long and deep fiords, indicate, according to all received views of the origin of such formations, that the land was formerly higher, while signs of glaciation are everywhere present.

The results of geographical research show us that in many parts of the world climate must have greatly changed in comparatively recent times.

In the now arid regions of Northern Africa, Central North America, and in parts of Asia there is ample evidence that the climate was in times past more humid. In a remarkable paper on the causes of changes of climate, contributed

by Mr. F. W. Harmer to the Geological Society in 1901, which has not obtained the notice it deserves, it is pointed out how changes in the distribution of the prevalent winds would vastly alter climatic conditions. Like everything else in Nature, and especially in the department of meteorology, these questions are exceedingly complex, and similar results may be brought about in different ways, but there can be no doubt that the climate of South Africa would be greatly modified, and more rainfall would occur, if only the cyclonic storms which now chase each other to the eastward in the ocean south of the Cape of Good Hope could be prevailed upon to pursue a slightly more northerly line, and many obstacles to the agricultural prospects of South Africa now existing would be removed. This is, however, beyond the powers of man to effect; but, as I have just said, there are other ways of attaining the object, and it is earnestly to be hoped that the attention now being paid to afforestation may result in vigorous efforts to bring about by this means the improvement in humidity so much required in many parts of the country.

The other recent event in geographical exploration is the result of the expedition to Lhasa. It was an unexpected solution of this long-desired knowledge that it should come from political necessities and by means of a Government mission. The many ardent travellers who have dreamed of one day making their way in by stealth have thus been disappointed, but our knowledge is now fuller than could otherwise have been gathered.

The most important fact is the revelation of the fertility of a large part of Southern Tibet. Much has been added to topographical knowledge, but the route maps of the secret Indian native surveyors already had given us a rough knowledge of the country on the road to Lhasa. It was not, however, realised how great was the difference between the aridity of the vast regions of the north, known to us from the travels of men of various nationalities, and the better-watered area in the south, though from the great height of the plateau—some 12,000 feet—the climate is very severe. The upper course of the Brahmaputra has been traced by Captain Ryder, but, unfortunately, a political veto was placed on the project to solve the interesting problem of how this great river finds its way to the Indian plains, and this still remains for the future to unravel.

Of the ocean, which has been my own particular study for many years, and on which alone I feel any special qualification to speak, I have said but little, for the reason that when presiding over this Section on a former occasion I took it for my theme, but there are a few points regarding it which I should like to bring to your notice.

It is of the ocean, more than of any other physical feature of our globe, that our knowledge has increased of late years. Forty years ago we were profoundly ignorant even of its depth, with the exception of a few lines of soundings then recently taken for the first submarine telegraph cables, and consequently we knew nothing of its real vast bulk. As to the life in it, and the laws which govern the distribution of such life, we were similarly ignorant, as of many other details.

The 'Challenger' expedition changed all this, and gave an impetus to oceanographic research which has in the hands of all nations borne much fruit.

Soundings have been obtained over all parts of the seas, even in the two polar seas; and though much remains to be done, we can now form a very close approximation to the amount of water on our earth, whilst the term 'unfathomable ocean' has been shown to have been based on an entire misconception. Biological research has also revealed a whole world of living forms at all depths of whose existence nothing was known before.

In my former Address, eleven years ago, I gave many details about the sea, of which I will only repeat one—which is a fact that everyone should know—and that is, that the bulk of the ocean is about fourteen times as great as that of the dry land above water, and that if the whole of that land were thrown into the Atlantic Ocean it would only fill one-third of it.

Eleven years ago the greatest depth known was 4,700 fathoms, or 28,000 feet.

We have since found several places in the Pacific where the depth is nearly 5,170 fathoms, or 31,000 feet, or somewhat higher than Mount Everest, which has been lately definitely shown to be the culminating point of the Himalayas. These very deep parts of the ocean are invariably near land, and are apparently in the shape of troughs, and are probably due to the original crumpling of the earth's surface under slow contraction.

The enormous area of the sea has a great effect upon climate, but not so much in the direct way formerly believed. While a mass of warm or cold water off a coast must to some extent modify temperature, a greater direct cause is the winds, which, however, are in many parts the effect of the distribution of warm and cold water in the ocean perhaps thousands of miles away. Take the United Kingdom, notoriously warm and damp for its position in latitude. This is due mainly to the prevalence of westerly winds. These winds, again, are part of cyclonic systems principally engendered off the coasts of Eastern North America and Newfoundland, where hot and cold sea-currents, impinging on one another, give rise to great variations of temperature and movements of the atmosphere which start cyclonic systems travelling eastwards.

The centre of the majority of these systems passes north of Great Britain. Hence the warm and damp parts of them strike the country with westerly winds, which have also pushed the warm water left by the dying-out current of the Gulf Stream off Newfoundland across the Atlantic, and raise the temperature of the sea off Britain.

When the cyclonic systems pass south of England, as they occasionally do, cold north-east and north winds are the result, chilling the country despite the warm water surrounding the islands.

It only requires a rearrangement of the direction of the main Atlantic currents wholly to change the climate of Western Europe. Such an arrangement would be effected by the submergence of the Isthmus cf Panama and adjacent country, allowing the Equatorial Current to pass into the Pacific. The gale factory of the Western Atlantic would then be greatly reduced.

The area south of the Cape of Good Hope is another birthplace of great cyclonic systems, the warm Agulhas Current meeting colder water moving up from the Polar regions; but in the Southern Ocean the conditions of the distribution of land are different, and these systems sweep round and round the world, only catching and affecting the south part of Tasmania, New Zealand, and Patagonia.

In 1894 I spoke of the movements of the lower strata of water in the sea as a subject on which we were only beginning to get a little light. Since that year we have learnt a little more. It is a common idea that at the bottom of the sea all is still; but this is a mistake, even for the deepest parts, for the tidal influence reaches to the bottom and keeps every particle in motion, though such motion is quiet and slow.

Near the shore, however, though still in deep water, the movement may be considerably increased. Cases have occurred in late years where submarine cables have broken several hundred fathoms deep, and when picked up for repair it has been found that the iron wire covering has been literally rubbed away as by a file. This can only be the result of an undercurrent along the bottom moving the cable to and fro. Such a current might be caused by a submarine spring, for there is no doubt that much fresh water finds its way into the ocean in this fashion, but it is more probably generally an effect of acceleration of the tidal movement due to the rising slope of the continent.

In connection with this, further facts have come to light in the course of recent marine surveys.

Many isolated shoal spots in the great oceans have figured in our charts, the results of reports by passing ships who have said they have seen breakers in fine weather.

Such places are the terror of seamen, and it is part of the duty of surveying ships to verify or disprove them. Very much has been done in the last eighteen years, with the result that the majority of them have, as dangers, disappeared. In

many cases, however, a bank has been found, deep in the ordinary acceptation of the word, but much less deep than the surrounding sea—solitary ridges, in fact, rising from the ocean floor. Frequently, in examining these banks in search of shoaler spots, breakers have been reported and recognised as such on board the surveying ship from a distance, but on approach they have proved to be small overcurls caused by tide ripplings, and the depth of water has proved to be several hundred fathoms. These ripplings are clearly caused by the small tidal motion in the deep water, generally in these cases of over 2,000 fathoms, meeting the slope of the submerged mountain range, being concentrated and accelerated until the water finally flows up the top of the slope as a definite current, and taking the line of least resistance, that to the surface, makes itself visible in the shape which we are accustomed to associate with comparatively shallow water.

These cases form remarkable instances of the manner in which extensive motion of water may arise from very small beginnings.

An observation I was anxious to make in 1894 has been successfully carried out since. This was to ascertain whether there was any permanent undercurrent in the Straits of Bab-el-Mandeb due to more water being forced through the strait on the surface by the persistent S.E. wind of winter than could be evaporated in the closed Red Sea.

Such return undercurrents have under somewhat similar circumstances been shown to exist in the Dardanelles, Strait of Gibraltar, and in the Suez Canal.

The observation at Bab-el-Mandeb was difficult. The wind is strong and the disturbance of the sea is considerable, while the water is 120 fathoms or 700 feet deep. But a surveying vessel maintained herself at anchor there during four days, and, by the aid of an ingenious apparatus sent from England for the purpose, clearly proved the existence of a current of 1½ knot flowing steadily at depths below 70 fathoms out of the Red Sea, whilst in the upper strata there was a similar current flowing in. In such ways is interchange of water provided for by Nature in places where tidal action does not suffice.

In what I fear is a very discursive Address I have not mentioned the interior of Africa. In the first place, it is a subject of itself; and as we shall have, I hope, many papers on African subjects I have thought it better to deal mainly with generalities.

Still I cannot refrain from a few words to express the astonishment I always feel when I hear people complain that Africa goes slow. When I look at what has been effected in my own lifetime, it appears to me that, on the contrary, it has been rushed. The maps I learnt from as a boy showed the whole interior as a blank. There are now no parts that are not more or less known. The great lakes have all been revealed; the great rivers have all been traced; Europeans are now firmly fixed with decent governments in parts formerly a prey to tribal wars and the atrocities of the inland slave traffic. Railways are running over regions unknown forty years ago, and one of the most astonishing things to me is that I should be able to hope now to visit in comfort and luxury the great Victoria Falls which my old friend Sir John Kirk—whom I left the other day hale and hearty—was, with the exception of Livingstone, the first white man to see, after a long and laborious journey in his company in 1860.

I could not help being amused as well as interested at seeing a short time ago a proclamation by the Government of Northern Rhodesia, dated not far from Lake Bangweolo, calling on all concerned to observe neutrality during the present war between Russia and Japan. I think that if anyone had prophesied to Livingstone, as he lay in 1873 lonely and dying by the shores of that newly discovered lake, that such an edict would be issued in thirty years he would have expressed a doubt as to its fulfilment.

To Southern Africa Nature has denied two of the features that facilitate rapid progress—good harbours and sufficient rainfall—but the energy of man has done wonders to provide the former where possible, and will doubtless do more; whilst I believe that the lack of the latter will also be overcome in the same way. The co-ordinated—or, in other words, the scientific—observations made in many other countries have pointed out a possible solution. On the other hand, the height of the

inland plateaux makes it possible for the white man to live and work in latitudes which would under other conditions be tropical.

South Africa must have a great future before it; and while some present circumstances may delay development of its natural advantages, I am inclined to think that in the long run prosperity may be more solid and material for being made in the face of difficulties, as has so often occurred in the history of the world.

The following Papers were read:—

1. *A Short Description of the British Ordnance Survey, and some Advantages to be gained from a Topographical Survey of South Africa.*[1] *By* Colonel D. A. JOHNSTON, C.B.

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2. *British National Antarctic Expedition with the 'Discovery.'* *By* L. C. BERNACCHI.

THURSDAY, AUGUST 17.

Joint Meeting with Section C.—See page 393.

FRIDAY, AUGUST 18.

The following Papers were read:—

1. *The Unveiling of the Coast of Africa.* *By* H. YULE OLDHAM.

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2. *The Visit of the Scottish Antarctic Expedition to Diego Alvarez, or Gough Island.*[2] *By* R. N. RUDMOSE BROWN.

This volcanic island, it was pointed out, was some 1,500 miles west by south from Cape Town. It was eight miles by four, bordered by steep cliffs 200 to 1,000 feet high, the land rising more gradually, with picturesque ridges and valleys, to 4,380 feet. The rainfall was great, and the streams formed fine waterfalls where they fell over the sea cliffs. One or two valleys had been cut down to sea-level, and formed the most convenient landing-places. Owing to the stormy seas landing was difficult. The vegetation was abundant, and the Scottish expedition discovered three new species of plants, two new buntings, and a rich marine fauna. The further exploration of the island was much to be desired, and should be undertaken from Cape Town.

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3. *The Indigenous Forests of South Africa.*[3] *By* E. HUTCHINS.

The forests of South Africa may be divided broadly into three classes: (1) The dense evergreen indigenous forest of which yellowwood is the chief species, and

[1] Published in full in the *Scottish Geographical Magazine*, January 1906.
[2] Published in the *Scottish Geographical Magazine*, August 1905.
[3] Published in full in the *Geographical Journal.*

which is commonly known as the yellowwood forest. (2) Open timber forest. This generally occupies drier country than the yellow forest, and is forest of an inferior type, though it may contain trees of the first importance, such as the cedar forest of Clanwilliam and the Rhodesian teak (*Afzelia cunanzensis*) forest of Wankie. (3) The scrub forests of the dry, hot, coast lands, and portions of the interior where the rainfall is scanty and uncertain.

There is no timber of large size in the scrub forests, and not much large timber in the open timber forests: the most notable is the cedar forest north of Cape Town, comprising an area of 116,000 acres. Leaving the western coast and its cedar forests the dense yellowwood forest is met as soon as the southern coast is reached. The indigenous yellowwood forest of South Africa is seen at its best in the form of dense evergreen woods disposed roughly in two stories. The lower story is formed by stinkwood, assegai, hard pear, ironwood, &c., and the upper story by the big yellowwood trees. These yellowwood trees attain the stature and dimensions of the largest oak trees of Europe. This forest stretches in a more or less broken belt along the coast mountains from Table Mountain to the north-east of the Transvaal. The area of the yellowwood forest in Cape Colony, Natal, and the Transvaal amounts to about 524,408 acres. Across the Limpopo, in Rhodesia, the forest is at a lower altitude and of quite another type. Most of the Rhodesian trees are leaf-shedding, and practically all of the species are different from those in the yellowwood forest. This sudden change in the character of the forest is remarkable. In the north-east Transvaal, on the Woodbush Range, essentially the same forest as at Knysna is seen, and only a few species are changed in the long stretch of 1,200 miles from Cape Town to the north-east Transvaal. The climate remains much the same, altitude compensating altitude. Beautiful though the indigenous yellowwood forest of South Africa is, its present economic value is not high, mainly owing to its poor stocking. The average yearly production of timber throughout the forest has been variably estimated at from 6 to 12 cubic feet per acre. Probably 10 cubic feet might be taken as a safe average figure. It is the work of the South African forester to improve the stocking of the indigenous forests with the native trees by cuttings arranged to favour natural reproduction, and at the same time to enrich the forest by the introduction of the best of the nnmerous valuable timber trees which are to be found in the extra-tropical forests of other countries. Of such trees the author cited particularly *Cedrela australis*, the premier timber tree of the Australian forests, and *Sequoia sempervirens*, the finest timber tree of California, and probably of the world. Other two trees which are doing well as planted trees are blackwood (*Acacia melanoxylon*) and the camphor tree (*Cinnamomum camphora*). Blackwood spreads rapidly with self-sown seedlings, and has a timber like walnut. It is hoped that these trees, introduced into the glades and artificial openings in the forest, will gradually spread themselves into the poorly stocked areas around and greatly increase the present low value of the indigenous timber forest of South Africa.

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4. *The Climatology of South Africa.* By CHARLES STEWART, *B.Sc.*

The author said that South Africa consists essentially of a series of four plateaux, increasing in elevation from south to the interior: (1) Coast Plateau, (2) Southern or Little Karroo, (3) Central or Great Karroo, (4) Northern Karroo, or, more properly, the High Veld. These plateaux were most distinctly marked in a section from north to south through the centre of the country, but were not so apparent in the east and west, where they were reduced to mere terraces.

Temperature.—One of the most remarkable features in connection with temperature was the great uniformity in mean annual temperature shown by stations differing widely as regards latitude and longitude; *e.g.*, Royal Observatory, Cradock, Bloemfontein, and Johannesburg had practically the same mean temperature of about 62° F. This was due to decrease of temperature with increase of elevation above sea-level, almost neutralising the increase of temperature which would

otherwise occur with increased intensity of solar radiation due to a nearer approach to the equator.

A closer examination showed an increase of temperature along the coast, from north to south along the west coast, from west to east along the south coast, and from south to north along the east coast, due chiefly to the modifying influence of the cold Benguela current in the west and the warm Mozambique current in the east.

The extremes of mean temperature were Disa Head (2,500 ft.), part of Table Mountain in the Cape peninsula, with 54°·7 F., and Tuli in Rhodesia in the Shashi Valley (1,750 ft.) with an annual temperature of 72°·4 F.

The average temperature of ninety-seven stations scattered over South Africa was 62°·8 F., or nearly the same as Sydney, N.S.W. The mean temperature curve was at its maximum in February, fell rapidly till June, continued to fall slightly in July, then rose, with a peculiar flattening of the curve in September, to the maximum in February. The continued fall in the July mean temperature was closely associated with a peculiar and, apparently, regular cold spell about the middle of the month; the minimum for the year occurred on July 16 over the Cape peninsula, and on July 17 at Kimberley. The flattening in September was associated with an increase in the cloud-curve, which was coincident with the change of the prevalent wind-direction from north-west in August to south in September.

Rainfall.—This curve showed two maxima—one in November and one in March—the minimum occurring in July. A comparison of the thunderstorm-distribution curve showed that the two maxima in the rain-curve were not coincident with the two maxima in the thunderstorm-curve, the maximum in the latter occurring in February (month of maximum mean temperature) and falling till June, then rising again to the maximum in February, with a dip down in November. South Africa might be divided into three rainfall areas according to its seasonal distribution: (1) winter-rainfall area in the west, (2) constant rains (small area) in the south, and (3) summer rains in the east. In Cape Town and the west generally the rain fell chiefly with north-west winds, with south-west along the south coast, and with south-west and some north-east along the east coast. There was little evidence in support of the 'south-east rain' theory, which would apparently have to be abandoned so far as the coastal areas were concerned.

Berg Winds.—These were fœhn-like winds experienced practically all along the coasts blowing from off the plateaux at right angles to the coast-line, being easterly in west, northerly along south coast, and north-westerly in the east. Those at Port Nolloth caused the winter temperature there to be higher than that at Ookiep (the reverse holding during the rest of the year), and actually delayed the occurrence of the minimum mean temperature till August. These were closely connected with the occurrence of secondaries, especially during autumn and the early spring.

Storms.—The storms visiting South Africa seemed to be closely connected with moving anticyclones and assumed apparently and principally the forms of inverted V-depressions, as in Australia.

Sunshine.—The largest proportion of sunshine occurred in the Cape peninsula in summer and was lowest in winter; whereas at Kimberley, which was typical of the greater part of the central plateau regions of Cape Colony, the largest proportion of sunshine occurred in the winter months, when the days were mostly bright and cloudless, although the night temperature was frequently low (below freezing-point) and severe. This fact had an important bearing on the suitability of the Karroo for phthisical patients and other invalids.

JOHANNESBURG.

TUESDAY, AUGUST 29.

The following Papers were read:—

1. *The Sikhim Himalayas and Tibet.* *By* Douglas W. Freshfield, *M.A.*

2. *The Physical Features of the Transvaal.*[1] *By* Tudor G. Trevor, *F.G.S.*

3. *The Triangulation of the Johannesburg Gold Fields.*[2] *By* C. van der Steer.

4. *Geographical Notes on Africa South of the Limpopo.*[3] *By* F. S. Watermeyer.

The author gave a brief historical sketch of the cartography of South Africa, traced the history of its population, and discussed the physical features and climatic phenomena that presented themselves with regard to their influence on the development of the pastoral and agricultural industry of the country. His history of the cartography of Africa commenced with a description of the map of Herodotus and concluded with the geodetic survey now being conducted under the supervision of Sir David Gill. The distribution of native races was described, and an historical sketch of the European colonisation of the sub-continent was incorporated from the Cape census returns. He said that the best watered part of the country was along the eastern slopes of the Drakensberg, and the best wheat-growing parts were on the west coast of Cape Colony from Elephant's River to Mossel Bay and the strip along the western slopes of the Drakensberg. The Agricultural Department of the Transvaal was doing yeoman service in proving the capabilities of the country for agriculture and stock-farming.

WEDNESDAY, AUGUST 30.

The following Papers were read:—

1. *Artificial Globes and their place in Geography.* *By* Captain E. W. Creak, *C.B., R.N., F.R.S.*

In view of the world-wide extent of the British Empire and the extent of its commerce, it is at least very remarkable that a lack of geographical knowledge prevails to a large extent amongst our people. The telegraph has placed us in almost daily communication with all parts of the habitable world, yet, even of those parts where live our colonial kith and kin, how much ignorance there is in the British Isles of the relative positions of those parts, their distance apart, and general distinctive features.

Little has hitherto been done to remedy this; but there are unmistakable signs

[1] Published in full in the *Geographical Journal*, 1906.

[2] Published in the *Journal of the Institute of Land Surveyors of the Transvaal.*

[3] Published in full in the *Scottish Geographical Magazine* for December 1905 and January 1906.

that the importance of geographical knowledge is becoming more and more recognised; and surely it is time that it should be so.

In our elementary schools it is clear that geography is often badly taught, and only by maps; even where terrestrial globes are provided, they are misused. In our great public schools there is also great neglect of geography, want of time being often the excuse for its omission, or, at best, for its casual introduction.

What should be the basis of sound geographical education? Certainly not maps, but globes. This view is strongly supported by such authorities as the late Professor Elisée Reclus, of Belgium; Professor Michael Sadler; Mr. H. J. Mackinder, who, spoke strongly in this sense at the Southport meeting of this Association; and, lastly, by Lord Kelvin, who wrote last year: 'In respect to schools it has been a very retrograde movement, the neglect, the almost total cessation of the use of the globes.'

Although teaching should begin in the home, we must look for the present to the 'dame schools,' or wherever the youngest children are taught, and there no map should be allowed to be used until the little ones have become familiar with the artificial globe, as the best available illustration of the natural globe they inhabit. Then, as we cannot indefinitely increase the size of globes, maps may be introduced to show the details of small areas of the parent artificial globe on a large scale. Maps on Mercator's projection should be excluded until a late date in education.

Even in public and private schools the globe should still hold a place—so much can be taught by it in the practical and intelligible solution of spherical triangles, in astronomy and navigation, as well as geography.

Assuming that the use of globes is the only sound basis of teaching geography, may it not be expected that if we so train up our children, then when they are old they will not depart from it?

A globe, or a familiar acquaintance with it, is an absolute comfort, as well as an invaluable aid, to the man or woman who wishes to read a book or even the morning paper intelligently, let alone its great value in studying terrestrial magnetism and seismology.

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2. *Excursions as a means of Teaching Geography.* *By* J. Lomas, *F.G.S.*

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3. *The Cycle of Geographic Forms in an Arid Area.*[1] *By* Professor W. M. Davis.

Assuming the existence of an arid region where the rainfall was practically nil, or so small that no rivers were formed, the water being absorbed before travelling more than a short distance, the inevitable action of such conditions upon the surface of the country was shown. Starting with a rough and uneven country, when slight rainfall occurred the water would run down the slopes and collect in hollows. In course of time the slopes would be worn down until two or more basins joined, then gradually the waste would all become deposited on the lowest level or basin. It would not remain a flat surface, for wind effect must be taken into consideration, particularly in such an arid region. The wind would blow the waste about and remove it, and the surface rock would be exposed or only slightly covered, and eventually the surface might be planed down below the level of the ocean. The author thought 'pans' might be the result of wind excavation in a more arid period than now prevails.

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[1] Published in full in the *Geographical Journal*, January 1906.

FRIDAY, SEPTEMBER 1.

The following Papers were read:—

1. *The Game Preserves of the Transvaal.*[1]
By Major STEVENSON HAMILTON, *D.S.O.*

2. *Boundaries and Areas in Africa. By* J. BOLTON.

This paper was confined mainly to a general reference to the boundaries of British colonies, protectorates, &c., with special reference to those boundary treaties and agreements that have resulted in boundary surveys, these surveys being almost the only pieces of scientific map-making in the whole continent of Africa.

The colonies and protectorates in the Northern Torrid Zone were treated very briefly, as here there is little or no room for white colonisation, and there is no white resident population. In this group comes, first in order, *The Colony of the Gambia,* with a boundary described only, and not surveyed, leaving room for dispute or arbitration, both equally to be avoided. Next comes *The Colony and Protectorate of Sierra Leone,* with boundaries surveyed and mapped, the northern part by Colonel Trotter (the Anglo-French Boundary Commission, 1895–96) and the eastern part by Captain Pearson (the Anglo-Liberian Boundary Commission, 1903). These boundaries, which were at one time pregnant with trouble, are now admirably fixed, and are not likely to breed international mischief. Then follows *The Gold Coast Colony,* a very ancient British possession, the boundaries of which have been surveyed by an Anglo-French Boundary Commission in 1901–03 on the Ivory Coast frontier, and by an Anglo-German Boundary Commission in 1905 on the Togoland frontier. The boundary between the northern territories and the French Sudan was surveyed by an Anglo-French Boundary Commission in 1900, reducing the possibility of disputes to a minimum.

The Colony of Lagos has only its western boundary common to another nation, and this boundary was surveyed in 1896–97 by an Anglo-French Boundary Commission.

The Niger Territories, occupied by British merchants in the coastal region for upwards of two hundred years, have been created a British possession by the energy and persistence of one man, Sir George Taubman Goldie. The boundaries of the portion now known as Northern Nigeria have been surveyed between the Niger and Lake Chad by Lieut.-Col. Elliot, R.E., with the Anglo-French Boundary Commission of 1902–03, and from the Benue River to Lake Chad by Col. Jackson, R.E., with the Anglo-German Boundary Commission of 1903–04. Unfortunately the Anglo-French Agreement of 1904 was negotiated before Lieut.-Col. Elliot, or his surveys, could reach home, and the alterations conceded by the Agreement may necessitate another Boundary Survey Commission. On the extreme east lies *The Somali Coast Protectorate:* here several boundary agreements have been made with the bordering Powers, but the boundaries have only been described on paper, have not been surveyed, and are consequently open to dispute.

Uganda and British East Africa have but indefinite boundaries on the north and east. On the east a survey of the Juba River from the coast to latitude 20° 30′ N. was made by Commander Dundas in 1892; but this cannot be considered a boundary survey, and, moreover, modifications—concessions to Italy—have been made recently that will necessitate a survey here.

On the south boundary surveys have been made from the coast to Mount Kilimanjaro by Mr. Smith in 1892; from Mount Kilimanjaro to Lake Victoria by Lieut.-Col. Smith, R.E., in 1904–05, and from the eastern shore of Lake Victoria to the Congo Free State boundary by Col. Delmé-Radcliffe in 1904. This completes the description of the boundaries of British possessions that lie entirely within the equatorial belt.

[1] Published in the *Geographical Journal,* 1906.

South of this belt lies that collection of colonies, protectorates, and Chartered Company's territory which at some future, but perhaps not distant, date is destined to become the powerful Commonwealth of South Africa. Only the outer boundary of this block is of an international character: this boundary commences on the Atlantic coast at the mouth of the Orange River, and is described in the Anglo-German Agreement of July 1, 1890. An accurate survey has been made of the German Bechuanaland boundary; and Captain Close, in 1898, with the Anglo-German Boundary Commission, triangulated the Nyasa-Tanganyika plateau and made an excellent survey and map of the boundary. The boundary of the Congo Free State has not been surveyed; but as it follows in large part a water-parting and a river bed, there is only small chance of disputes. The eastern boundary of this vast area commences at the parallel of 26° 30′ S. lat. The Delagoa Bay Arbitration line, the boundary common to Portugal and the Transvaal Colony, was surveyed by a Portuguese Commission in 1890-91. From the Limpopo River to 18° S. lat. the boundary was surveyed by Major Leverson with the Anglo-Portuguese Boundary Commission in 1892, and this survey he continued in subsequent years to the Mazoe River.

In 1893 Mr. Sawerthal, with a Portuguese Commissioner, continued this boundary demarcation to the Zambezi River, and Dr. Rubin's triangulation party has surveyed the portion of the Loangwa River that forms the boundary here. From the Loangwa River to the British Central Africa Protectorate boundary the line is now being surveyed by Captain O'Shee, R.E. The British Central Africa and Portuguese boundary was surveyed by a Joint Commission in 1899. Finally the King of Italy's Arbitration Award Line will help to fix the boundary of the Barotse kingdom.

The vast area contained within the ring-fence just described is being rapidly traversed from south to north by a geodetic survey under the direction of the energetic Astronomer Royal, Sir David Gill. A complete topographical survey should now be undertaken.

The interior boundaries being but local matters we pass on to areas.

The area of Cape Colony is nearly five times the area of England and Wales.

The area of Orange River Colony is a little larger than England.

The area of Natal is considerably larger than Scotland.

The area of Basutoland is nearly twice the area of Wales.

The area of the Transvaal with Swaziland is much larger than the combined area of England and Wales and Scotland.

The area of British Bechuanaland, with the Tati district, is nearly twice as large as the United Kingdom of Great Britain and Ireland.

The area of Rhodesia is nearly four times the area of the United Kingdom.

The area of British Central Africa is equal to the area of Scotland and Wales.

The total area of this South African Commonwealth is 1,196,459 square miles.

Mineral areas, gold, copper, iron, coal; areas suited to ranching and stock-breeding, to the growing of cotton and tobacco, tea and sugar, corn and other cereals, were referred to by the author; and the prime necessities of the country were suggested to be: afforestation, irrigation, means of communication, and the execution of a good national topographical survey.

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3. *A new Rainfall Map of Africa.*
By A. J. Herbertson *and* P. C. Waite.

The authors have revised the map used ten years ago for Bartholomew's 'Atlas of Meteorology,' and have been able to amend it in details. They discussed the general laws of rainfall distribution in Africa. They also pointed out how by local investigations into the distribution of rainfall round any special type of land form under specified wind conditions the general map may be interpreted for local as well as general conditions.

Section F.—ECONOMIC SCIENCE AND STATISTICS.

President of the Section.—Rev. W. Cunningham, D.D., D.Sc.

CAPE TOWN.

WEDNESDAY, AUGUST 16.

The President delivered the following Address:—

Unconscious Assumptions in Economics.

Among the members of any such gathering as a meeting of the Economic Section of the British Association there are likely to be some who come to give information and some who come to get it. In the latter class may, I am sure, be included all those *habitués* of the Section who have seized the opportunity which the visit of the Association affords with the view of learning something about the present condition and prospects of the enormous territory which we hope to be able to traverse. It may not be so to the same extent in all Sections. Those who come from the great chemical and physical laboratories of Europe may have much to say as to the result of experimental investigation, which they can carry on under more favourable conditions than are at present generally available to students in South Africa. But in Economics there is no room for experimental inquiries consciously undertaken in the interest of the advancement of science. The issues are too serious; the conditions on which they depend cannot be arranged for the convenience of the inquirer. Economics is a science of observation, not of experiment; and we are fortunate to find ourselves in specially favourable circumstances for noting and appreciating the results of investigations which have been made by skilled observers on the spot.

While we gratefully acknowledge the pains that have been taken here in preparing papers for this Section, we may yet feel that the task we are setting ourselves as visitors is not an easy one. There are few harder things in this world than to preserve a genuinely receptive frame of mind, and hold the judgment in suspense when we are brought face to face with the unexpected. There are so many assumptions we all make, and so many canons of criticism we have habitually accepted, that are not easily laid aside, even temporarily. 'The worst use of theory,' as a great Cambridge professor has warned us, 'is to make men insensible to fact,'[1] and the danger may be most real when we are not aware of the influence exercised by some hypothesis which we habitually make.

I. The popular discussion of economic problems teems with unconscious hypotheses, which tend to obscure the facts of the case. Mill described political economy as a science which, assuming the facts of human nature and of the

[1] Lord Acton, *English Historical Review*, i. 40.

physical world, considers the laws of the production and distribution of wealth. But what are the facts of human nature which we may legitimately assume? At first sight we are inclined to take for granted that human nature is much the same all the world over. The late Professor Jevons gave clear expression to this view. 'The laws of political economy,' he says, 'treat of the relations between human wants and the available material objects and human labour by which they may be satisfied. These laws are so simple in their foundation that they could apply, more or less completely, to all human beings of whom we have any knowledge. He adds: 'I should not despair of tracing the action of the postulates of political economy among some of the more intelligent classes of animals.'[1] It has seemed as if in the march of progress modern industrial conditions must inevitably be introduced in backward countries, and that they would everywhere result in moulding individual aims and character on the same lines. Each individual is to some extent affected by his environment; and it has been supposed that the keen competition and struggle for existence, which in one form or another dominates economic life in all parts of the globe, would make for the survival in all areas of men of the type with which we are familiar in business circles at home. In England there is on the whole a condition of free exchange, where each individual puts in his quota of service to the community and bargains for payment. His success in the management of land is rewarded by an increase of rent; his enterprise in investing his capital, by larger profits; his diligence and skill as a workman, by the wages he draws. The man who is self-disciplined enough to follow routine work habitually for the sake of reward, and whose ambitions lie in the direction of better paid and more responsible service, is the normal man of such a society. But it must be remembered that modern civilisation is also producing another class; whatever the force of social environment may be, it does not, as a matter of fact, form each unit of the rising generation on the same type. There are men who do not fit readily into our modern system; they dislike the monotony and stationary life which steady industry imposes, though they may be able to work well and hard when the fit takes them. The tramp of the American continent is as much the product of existing industrial conditions as the ambitious leader of an organised body of skilled artisans. The 'ins and outs' of Great Britain have characteristics which may be described as nomadic.[2] Economists recognise that the fluidity of labour is one of the assumptions that can be fairly made in regard to modern society.[3] The conditions under which labour is fluid give opportunity for the growth of a half-employed and migratory class, who are, as a class, a tax upon the well-being of society. It is the greatest of all problems in the Old World to see how the educative influence of society can be brought to bear so that it shall rear as much as possible the sort of man who is 'capable of standing on his own feet and of contracting when and how to render services to those who are willing to offer services he wants in return.' The question, What is to be done with those who cannot and will not thrive on this system? is constantly presenting itself in new forms. For our present purpose it may suffice to recognise that this question exists, and that even when the conditions of race and history and social surroundings are similar they do not produce one type of individual only. Under these circumstances we can no longer take for granted that human aims and activities are becoming closely similar in all parts of the globe, even for economic purposes. The individual estimate of the utility and disutility of labour at any given moment may often be very different from that which the economist would assume to be the natural conclusion. It is obviously absurd to suppose of vast numbers of our fellow-creatures that they are in the habit of acting in accordance with what appears to be common-sense to the average travelling Englishman, but they need not necessarily be fools on that account.

II. What is true of unconscious assumptions in regard to individuals personally also holds good for the mechanism of society; we cannot assume that it

[1] W. S. Jevons, *Principles of Economics*, p. 196.
[2] J. C. Pringle in *Economic Review*, xv. 60.
[3] W. Bagehot, *Economic Studies*, 21.

works everywhere in the same way. The Classical Economists were inclined to limit their investigations to the areas and regions where free competition has been dominant, and thereby to exclude from consideration all those important problems which arise from the contact of individuals of two races, with different economic habits and ideals, upon the same soil. But even if the ages and areas of free competition could be cut off from the rest of the world, and we fixed our attention exclusively on this single plane, we should not find simplicity and uniformity throughout the whole region. The habits of business practice and labour organisation differ in different lands: the banking system in Scotland is by no means the same as that in England, and a form of currency which finds favour in one is illegal in the other. There is also a want of complete conformity between the Eastern and the Western States in this matter; we cannot argue directly from the one to the other. When this is true about the medium of exchange, it is obvious that the differences between one highly advanced community and another in regard to the terms on which labour is carried on, or the method in which land is managed, will be even more striking.

The great difference in the working of the mechanism of society, as we know it in England and as we find it in other lands, was the chief impression which was left on my mind on the occasions when I have had the opportunity of travelling far afield. A quarter of a century ago it was my good fortune to spend a few months in India, and to get some insight into the extraordinary contrasts between Britain and her great Dependency. At that time many of the changes which had revolutionised English industry and internal traffic were beginning to make themselves felt throughout India. Railway communication was being opened up in all directions, and cotton spinning was carried on at mills in Bombay, and in Hyderabad in the Deccan. The results of the age of mechanical invention had begun to invade the changeless civilisation of the East. Still the persistence of the old order was also noticeable. The village community, as an exclusive group, with the headman who supervised all transactions with the outer world, forced itself upon my attention when I attempted to hire a pony to visit the cave at Karli. I passed a granary in Kathiawar where the officials of a native State were measuring out the crop and collecting the revenue in kind. The highly developed gild system at Ahmedabad was the very image of much that I had read of regulated industry in mediæval towns. On every side it seemed as if the survivals of the past had been preserved in the East, so as to make the story of bygone ages in the West alive before my eyes. On the other hand, the transition from the old to the new, which had gone on steadily in England for centuries, seemed to be ready to sweep over Hindustan like a flood, that would disintegrate existing institutions, while it showed little constructive power. And when I heard discussions on the incidence of taxation, the pressure of the salt tax, or the impossibility of imposing an income tax, I at least realised that the conditions were strangely unlike those of which a Chancellor of the Exchequer would have to take account in England. The mechanism of society is entirely different; the expedients which would make for convenience and equality and inexpensiveness in England would not necessarily be feasible in India at all.

Five years ago I had occasion to reside for some months in the United States, and once again I came away with a strong impression that the mechanism of society was very unlike that with which I am familiar in England—the differences were more subtle, but not less real, than those between English and Indian economic life. Throughout the States there are few vestiges of past history; the alleged relics of Norse invasion have disappeared under the solvent of critical investigation; and though frontier life has been till lately an abiding factor in American civilisation, comparatively little influence has been exercised by the native races on the economy of America to-day. The English stock, with grafts of many kinds, has had a clear space in which to grow. In India the conflict of the past and the present seemed to be the dominating condition, but in America there had been room for the development of a new country pure and simple, unhampered by the traditions and customs of bygone days, except in so far as their wisdom was confirmed in present experience. Hence, on the other side of the Atlantic the

practical economic problems as to the development of a large and wide territory are presented in their simplest form. It is there that we can note most clearly the lines on which modern industry and commerce develop with the full employment of modern appliances and the minimum of control from traditional habits and institutions.

There is one economic conception which is deeply ingrained in English habits, and which seems to me to have no corresponding hold in America—that of the market. Its former importance as the centre of trade in many towns is sufficiently vouched for by the space that it occupies, and its legal history takes us back to the very beginning of urban life in England. In mediæval opinion a sale in open market, where buyers and sellers met together publicly, had all the guarantees of an honest transaction; it was important both as evidence of the sale and as an indication that the bargain was above board and fair, since there was one price for all alike. Private transactions which did not come into the market—forestalling and such like—were viewed with suspicion; they were supposed to be methods by which some wily person drove an extortionate bargain or gained at the expense of others. And, in modern times, organised markets, where there are facilities for public information, are common, not only in every locality, but in a great variety of trades. Commercial transactions in the United States seem to have sprung up and developed on rather different lines; markets are frequented in the country towns of Lower Canada, but there is little sign of them in the cities of the States. It almost seems as if commercial practice there were based on the habit of 'having a deal' privately, and took its character from transactions outside a market rather than from the higgling which occurs where many buyers and sellers meet. There can, at least, be little doubt that the methods of bargaining which are current in the States have been favourable to the building up of great organisations—both the industrial organisations which control all parts of some industrial process, and the trusts which monopolise some line of business. The lack of public markets, either for produce or for goods, at various stages of the process of manufacture, has apparently rendered it easier to form great monopolies in America than it would have been in Great Britain. Indeed, it may almost be said that the struggle for existence among business rivals takes a different form in the two countries. As Professor Jenks points out, the whole terminology which is habitually employed to analyse the movements of prices in England is inapplicable to the United States. 'The normal price of economists has been based upon cost of production under a system of competition among small capitalists.' But in such an industry as sugar-refining, in the United States, this condition does not hold good. 'There is no normal level of competitive price based on the cost of production.'[1] The whole industrial organisation takes other forms, and the mechanism of competition does not work in the fashion which English economists would assume. We have need to be doubly on our guard, since unconscious assumptions may not only affect our powers of observation, but may also be present to colour the language we use in describing unfamiliar phenomena.

III. It is not easy to overrate the services which the Classical Economists rendered in their day to the progress of Economic Science, owing to the clearness of the conceptions they applied to the limited field they studied, and to the accuracy they endeavoured to introduce in regard to the use of familiar languages. It was their misfortune, rather than their fault, that their manner of treating individual human nature and the mechanism of society has given some excuse for the popular misuse of their teaching. In the public mind, principles which had been legitimately put forward as convenient hypotheses for the investigation of a particular sphere have been transmuted into axioms of universal applicability. But when we turn to other subjects of economic inquiry, the limitations, and consequent defects, of the Classical school become more apparent. The idea of the growth of society was not easily brought within the limits of a system which makes so much use of terminology borrowed from physics. Some of the precursors of Economic Science in England had treated national life as organic, and had relied

[1] J. W. Jenks, *The Trust Problem*, p. 141.

on biological conceptions. Hobbes had devoted a chapter of the 'Leviathan' to the nutrition and procreation of States;[1] and Sir William Petty, who had held the Chair of Anatomy in the University of Oxford, entitled an important statistical work 'The Political Anatomy of Ireland.' But another and less fruitful habit of thought existed side by side; the Mercantilists, in discussing the benefits of commerce, wrote much of the balance of trade; and the physical analogies they introduced—especially the notion of equilibrium—exerted a dominating influence over the form which the science took in the hands of the Classical Economists. These last were so much absorbed in the discussion of the mechanism of exchange and the mechanism of society that they failed even to recognise that it is essentially organic. As has been well said, 'the Classical Economists belonged to the pre-Darwinian age. We differ from them in our whole view of life and of the ends of life—in our whole mental method as well as in our possession of the practical experience of the last sixty years.'[2] It is only in recent years, when we have passed beyond the arbitrary limits they accepted and imposed, that it has been possible to enter on new fields of research. Carl Bücher[3] has brought out the importance of the relations which subsist between economics and anthropology, and Thorold Rogers proved himself a vigorous pioneer in the interpretation of history. In this fashion the whole range of the phenomena of economic life, in its earlier as well as in its later forms, is being brought within the sphere of scientific treatment as exhibiting various stages of growth. The men of the classical period of Economics, who devoted themselves to the study of new countries, were not in a position to deal with the subject properly, and their writings seem singularly lacking in grasp. Times have changed since their day, both politically and economically. Lord Brougham wrote at a date when responsible government was undreamed of; he pleaded for the benevolent treatment of dependencies, and his language is wholly inapplicable to the great self-governing nations which have been formed partly under English influence and partly through English neglect. But none the less is his writing, and that of some other enthusiasts for the development of the colonies, of abiding value as a monumental warning against a sort of pseudo-philosophic habit of mind. There is an underlying assumption that the one type of colony he had in mind was the only one worth taking into account; he was really thinking of a particular case, but he allowed himself to write of it in general terms, and thus to give an air of philosophical detachment to his remarks.[4] In the year 1803 there were many circumstances that gave prominence to questions connected with the West Indies; the agitation in regard to the slave trade was one, the trade rivalry between the French and Spanish and English islands was another. Brougham was thinking of the West Indies; all that he said of the dependence of these little islands on the Mother Country for defence, of the necessity of the colonists relying on English help to repel prospective invasions and annexation by France or Spain, was true enough; it might well lie at the basis of the economic relations between the planters and the Government in England, but it has no bearing on the actual conditions of the great continental countries which are still called colonies, and which are at least under no anxiety as to their ability to repulse a foreign invader.

The greatest of all Brougham's contemporaries who wrote on the art of colonisation was not exempt from a similar defect; he professed to write in general terms. Few names are more deserving of honour than that of Edward Gibbon Wakefield, and there is something very extraordinary in the contrast between the strong practical sense which distinguished him as a man of action, and the doctrinaire spirit which pervades his writings. He fell into the error which characterised the Classical school when they dealt with practical problems,

[1] Pt. ii. ch. xxiv., Camb. Univ. Press Edition, p. 175.

[2] J. L. Garvin, 'Principles of Constructive Economics,' in *Compatriots' Club Lectures* i. 2.

[3] *Arbeit und Rhythmus.* His *Industrial Evolution* has been translated by Dr. S. M. Wickett, and I desire to acknowledge my indebtedness to the volume.

[4] Lord Brougham, *The Colonial Policy of European Nations* (1803), i. 108.

and generalised from the special conditions of his own day.[1] There was, to Wakefield's mind, one, and one only, method of successful colonisation; all others were to be condemned in so far as they departed from the true system which he had devised. Wakefield, too, was the victim of unconscious assumptions; the type of colony he had in mind was a white man's country, in which raw produce might be obtained for export. He showed under what conditions Australia, Tasmania, and New Zealand might be most successfully developed;[2] but his scheme is certainly unsuited to tropical regions, and it need not necessarily be preferable to the alternative of developing a community on the lines of subsistence farming. On this point at least we can make a very definite comparison: Virginia, Carolina, and Georgia have all been colonies which raised such commodities as tobacco and rice and cotton for export; they started more rapidly than the New England colonies, where the settlers were engaged in subsistence farming; but as we look at these States at the present time, we can hardly say that the type of community to which Wakefield devoted exclusive attention is that which has given rise to the most healthy and vigorous economic life.

Even Adam Smith, in writing of the growth of societies, fell into a similar error: he passed out of the region of actual life, where he showed himself such a master, and attempted to discourse in a pseudo-philosophical strain on the manner in which countries ought to have developed, but never had. He allowed himself to elaborate an account of a supposed natural progress of opulence, which might have occurred in an isolated state. There is scope for a pretty play of fancy and much elegant writing in such a theme, but no attempt was made to show that isolated states ever do develop, so long as they remain isolated. Much may be said for the view that the chief stimulus to development is supplied by contact with communities on a different plane of economic conditions. In the history of England there are long periods of apparent stagnation and decline, and occasional epochs of rapid advance; but, whether in the days of the Danes or the Norman kings, of the Edwards or the Georges, the opening up of new trading relations has been the impetus to internal development. Economic experts are not even yet acquainted with philosophical principles as to the manner in which communities ought to develop, and therefore we are not justified in pretending to train up a young country in the economic way it should go.

IV. Every undeveloped country presents a network of fresh problems, each of which must be studied separately; but they must also be considered as interrelated and viewed in their mutual dependence. There is a mass of experience in the past which may be drawn upon as a help; we may appropriate it, and save ourselves the expense of buying fresh experience in a costly fashion; but in order to reap the fruit of human experience in the past we must be prepared to take a great deal of trouble; it is not lying about for anyone to pick up at haphazard. The teachings of history as to the rise of great nations from small beginnings, or as to the causes which have led to premature decay, do not lie on the surface. Since the days when Lord Burleigh recognised that the mineral wealth of the Spanish conquests in the New World did not really add to the strength of the monarchy at home, there has been a tendency to disparage extractive industries. 'Moile not too much underground,' said Lord Bacon, 'for the hope of mines is very uncertain, and useth to make the planters idle in other things';[3] and Adam Smith does not at all dissociate himself from this view.[4] It appears to have been thought that mining for the precious metals, however attractive it might be for a time, could never be a secure foundation for the building up of stable society. But, after all, it would be wise to discriminate a little before we adopt this conclusion, and to examine the condition of different parts of Spanish America separately.[5] The richest mines of all, those of Peru, were situated on the arid slopes of the Andes, where cultivation

[1] Cunningham, *Growth of English Industry and Commerce in Modern Times*, p. 740.

[2] E. G. Wakefield, *Art of Colonisation*.

[3] *Essay on Plantations.*

[4] *Wealth of Nations* (Nicholson's Edition), 71, 73.

[5] Merivale *Colonisation and Colonies* (1861), 25 27.

was impossible, and there were insuperable obstacles to the planting of well-ordered and prosperous communities; but very different results were achieved in Mexico. These workings occurred on a plateau where cultivation and settlement were possible, and the wealth which was obtained by mining reacted on the prosperity both of agriculture and manufactures. Extractive industry served to give a stimulus to that varied life, partly urban and partly rural, which is necessary for a community that hopes to take a real and independent place in the civilised activities of the world. It is foolish to jump to the conclusion either that mining gives a feverish and unhealthy stimulus, or that the Spanish system of regulation was incurably bad; we ought to distinguish carefully, and to try to learn from Spanish experience, both in South and in Central America, what are the conditions under which mining for the precious metals can be pursued so as to be not merely of temporary, but of permanent advantage to the welfare of the community.

In fact, we must remember that the experience on which we rely in regard to economic growth has been obtained, not by experiment in a laboratory, but by observation in the world itself. The investigator in a laboratory can note all the conditions under which an experiment is conducted; he can be certain that under the same conditions the same result can be secured over and over again. But in the world of political and economic activities we never find the same conditions repeating themselves; the fundamental inquiry must always be, How far were the conditions of some growing community in the past similar to those of some growing community to-day? How far are they on all fours, so that we can argue from one to another directly? Sometimes we may get a very close analogy, and instructive comparisons may be possible; but even when the conditions are very different, when there is hardly any close parallel, we may still get a suggestion as to a mode of development that might prove fruitful or as to a danger which it may be well to bear in mind.

There is pleasure in completing, so far as the limits of time and energy allow, an empirical economic investigation; but to those who have any vigour of mind at all there is a keener delight in seeing new fields of possible inquiry opened up. It is very enjoyable to renew acquaintance with an old difficulty in a fresh form, or to find that some question which seemed to be settled is forcing itself clamorously on our attention for reconsideration; and hence we have, as economists, set out for our too hurried visit here with eager anticipation. The conditions of South Africa seem to be very different from those of any other part of the world, and therefore every particular economic problem presents itself in an unfamiliar aspect. There has not been such a clear field for the working out of new ideas as was presented in the great West, or even in Australasia; and all questions as to the opening up of the country and the economic aims and aspirations of the settler are necessarily more complex. There may not be the sharply defined conflict between the old and the new which renders British India such a fascinating field for study, but the African problems are not simplified on that account. It is, rather, true to say that there is additional complication with regard to all industrial activity in a land where the natives have not been schooled to regular habits of work by the discipline of a high traditional civilisation. As passing tourists we can obviously make little progress in understanding how these practical difficulties are to be solved, but at least we hope to learn to know better how the questions ought to be stated. We shall have our reward if we carry back with us as a cherished possession a not wholly unintelligent interest in the great economic problems which must be worked out in South Africa.

The following Paper and Report were read:—

1. *The Terms and Conditions of Domestic Service in England and in South Africa. By* Lady KNIGHTLEY OF FAWSLEY.

The great importance of domestic service in facilitating the work of the world is not sufficiently recognised. There are mutual obligations, as, on the one hand, we owe much to our servants, and, on the other, good mistresses make good servants.

There is in all parts of the world an increasing distaste to domestic service; but there are still many instances of long-continued service in the same household. Domestic service in England may be divided according to five distinct types of establishment. (*a*) Very large establishments, with steward's room. (*b*) Large country houses, with twelve servants or more. (*c*) Households with four to eight. (*d*) Houses with two or three. (*e*) Households with one general servant. The general servants are valuable in many ways, and, especially, are more adaptable than servants in establishments which are elaborately organised.

The conditions of domestic service appear to vary greatly in different parts of South Africa. Wages in the Transvaal are much higher than in Cape Colony or Natal. In the Transvaal, where some of the work is generally done by native 'boys,' emigrants from England are inclined to expect an unreasonable amount of help, and have much to learn as to the proper treatment of the native. This difficulty does not arise to the same extent in Cape Colony, but complications are sometimes due to the working of the Master and Servants Act, to which servants signing contracts become liable. It would probably be advisable that immigrant domestic servants should be bound to remain for two years in the Colony, but that these should not necessarily be spent in the same situation.

South Africa presents excellent openings for healthy, sensible, and adaptable young women, and movements for introducing them are likely to forge further links in the chain which binds the Colonies to the Mother Country.

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2. *Report on the Accuracy and Comparability of British and Foreign Statistics of International Trade.*—See Reports, p. 187.

THURSDAY, AUGUST 17.

The following Papers were read:—

1. *The Public Revenue of South Africa.* *By* H. E. S. Fremantle.

There are various special difficulties in the way of estimating the revenue of South Africa and tracing its growth and relation to the population. The language difficulty is considerable, as some of the old papers are written in Dutch of a style very different from that of to-day. In the old accounts many items not properly belonging to the accounts of South Africa are included. The same is to some extent true of the accounts of the South African Republic. The history of taxation is not easily traced. The scope of Government operations has greatly increased. On the other hand, after a centralising period there has been much decentralisation. Moreover, the accounts are questionable, as is shown by the large discrepancies between the Auditor-General's and the Treasurer's figures, especially in past years. No set principles are even now rigidly established. Other difficulties are those connected with Imperial expenditure, the difference of financial years, the question regarding the proper method of estimating the coloured population both before and after the annexation of native territories, and the old currency. Much is gained by an effort to adopt a uniform principle in dealing with each of these questions.

The ideal investigation into the movement of the revenue is not possible until the statistics, especially those of the past, are satisfactorily revised and presented. In this paper an attempt was made to present figures showing the population, the gross revenue, and the debt from 1687 to 1903, and to characterise the chief financial tendencies.

The main facts with regard to population are the large natural increase of both white and coloured races; immigration of Europeans before the close of the first decade and in the last quarter of the eighteenth century, at the end of the second decade of the nineteenth century, and after the discovery of the mines; and the

introduction of slaves, especially in the early years of the British occupation, and the immigration of the Bantu.

The revenue has partly been determined by the extravagance of early Governors. In Cape Colony there were three periods of direct taxation, followed by an inclination to substitute indirect taxation in 1842. Since then there have been two periods of direct taxation. Elsewhere the tradition of the old Colony has been strong, but the same tendency has shown itself.

The growth of the debt has been rapid since 1863, and though it is far less per head than the New Zealand debt, it is far greater than the English debt, which is, on the one hand, less due to reproductive works, but, on the other, is held in the country.

The figures show that, despite the changes of taxation, the relation of the revenue to the population has been remarkably steady. Since the beginning of the borrowing period taxation has increased in severity, but the expansion of the revenue has not been much more than is accounted for by the debt, and, considering the progress that has been made among the natives, is disappointing. The finance of South Africa has been to some extent casual. The figures and the actual circumstances which they represent suggest the desirability of a definite policy deliberately calculated to foster the internal resources of the country.

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2. *The Railways of South Africa.* *By* J. W. Jagger, *M.L.A.*

The facts that South Africa has no navigable rivers, and is therefore solely dependent upon its railways for its traffic from the ports to the inland plateau, and that they are for the most part State-owned, make them an important factor in the economics of this sub-continent.

Until 1870, when the diamond fields were discovered, there were only 65½ miles of railway in South Africa; but in 1884 Kimberley was connected with all the ports of the Cape Colony. The financial results were, however, very unsatisfactory until the year 1887, when the Transvaal goldfields were opened up. Then commenced a period of great prosperity, which lasted till 1902. The two years following showed a falling-off in traffic, decrease in rates, and increase in expenditure, with the result that interest on the capital invested was only partly earned. Through the exercise of rigid economy, however, the railways have in the last twelve months again paid full interest.

Natal has been greatly assisted by her coalfields, but otherwise the financial history of her railways is very similar to that of the Cape Colony.

The Transvaal railways started in 1891 with the Rand tram, which has since been connected with all South African ports. They are worked jointly with those of the Orange River Colony, and show excellent financial results on account of the great volume of traffic and the high rates.

There are several important railway problems in South Africa, such as the question of rates; and the difficulty that the commercial interests of the ports do not always agree with the financial interests of the different railway systems. On this account, and because a joint railway board would be independent of Parliamentary control, the federation of the South African railways should await the general federation of all the South African States.

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3. *The Protection of Infant Industries.* *By* H. O. Meredith.

This paper dealt with two questions:—

1. Whether it is desirable to grant protection to young industries.
2. What form, if any, should such protection take.

Difficulties in reaching a conclusion as to the effects of the protection of infant industries (*a*) by the historical, and (*b*) by the theoretical, approach were dealt with.

The principal arguments for and against such protection were advanced, and then the first question was left *sub judice*.

In dealing with the second question the relative advantages of 'bounties' and protective duties were considered, and a decision reached in favour of the former. The practical difficulty of using bounties was however admitted, and this difficulty was found to consist principally in the lack of a general understanding of economics. This led to a further discussion of the difficulties in the path of scientific protection. It was shown that ignorance has led protectionist nations on to wrong lines, and has produced unduly complicated tariffs, whose results cannot possibly be gauged with exactitude, but are probably, in the main, evil. It was suggested that if protection be practised, more simple methods should be employed—that the attempt to protect everything at once should be abandoned in favour of a concentration upon one industry at a time.

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4. *Rural Industries.* *By* G. Fletcher.

FRIDAY, AUGUST 18.

The following Papers were read:—

1. *The Development of the Wool Industry.* *By* T. H. Moore.

Whilst all sheep are descended from the six preserved by Noah from the Flood, climatic and other influences have brought about great variations throughout the world both in carcase and covering. Probably quite 80 per cent. of to-day's wool supply is obtained from the merino, from the heavy English sheep, and from crosses between the two.

Spain was originally the home of the merino, but Saxony, Silesia, and France (Rambouillet) all effected great improvements in the breed, and the magnificent flocks of Australia are chiefly descended from the German improved stock. The merino was first imported into the Cape by Mr. Michael Breda, of Swellendam, in 1787, and ten years later Captain McArthur obtained from the Cape the first merinos seen in Australia The South American flocks are descended from sheep originally introduced by the early Spanish settlers.

The world's supply of wool in 1904 is estimated by Messrs. H. Schwartze & Co. at 2,129,000,000 lbs., contributed as follows:—

United Kingdom	6·20	per cent.
Continent of Europe	21·14	,,
North America	14·33	,,
Australasia	24·11	,,
South Africa	3·35	,,
South America	22·23	,,
Other sources	8·64	,,
	100·00	

The home supply of the United Kingdom is decreasing, that of the Continent of Europe remains stationary, North American does not increase. The South American meat trade may develop the crossbred article still further, but merinos there must be near the maximum; Australia, now the prolonged drought is completely broken up, will probably increase its production 50 per cent. South Africa is eminently adapted for large increases of merinos, and no fear of over-production need be entertained. There never was, and never can be, too much wool grown. The consumption of clean wool in Europe and North America last year was 2½ lbs. per head of population. Half a pound increase would represent one million bales of Cape wool. Farmers should hesitate before attempting cross-breeding, but by judicious selection much may be done to improve the merino where acclimatised.

Compare the beautiful wool of Australia with the Spanish wool of to-day, and it is difficult to believe that a hundred years ago they were common stock. Crossing with the heavy English sheep may be satisfactory in temperate climes, within easy access of seaports, so as to cater for the frozen-meat trade, but for up-country South Africa the merino is best.

The longer the merino staple the more valuable it is; therefore the system sometimes practised in South Africa of shearing twice a year is unwise and improvident.

Suppose a man had a flock of one hundred sheep, and he sheared half the number each six months, the other half at the end of twelve months, the account would stand something like this:—

Six Months' Wool.				*Twelve Months' Wool.*			
500 lbs. @ 7*d*. . . .	£14	11	8	500 lbs. @ $8\frac{1}{2}$*d*. . . .	£17	14	2
Less cost of twice shearing	2	0	0	Less cost of shearing .	1	0	0
	£12	11	8		£16	14	2

Difference in favour of twelve months . £4 2 6

Machine-shearing is preferable to hand-shearing. Washing sheep before shearing is waste labour. Scouring the wool after shearing is, as a rule, undesirable, but in some instances is policy in South Africa. Too much stress cannot be laid upon classing and careful sorting. Clots of dung rolled up in the fleeces mean that the grower pays all cost of sending dirt to Europe and of picking it out when it gets there. The market of the world is London, and, notwithstanding the extent to which Australasian growers realise at home, values are fixed by London sales, and there a grower is certain of most competition, as buyers from all the manufacturing districts of the world (except Japan) are in daily attendance during the wool sales.

2. *Changes in the Sources of the World's Wheat Supply since* 1880. *By* A. L. Bowley.

Statistics were given showing the production, importation, and exportation of wheat of the principal countries from 1880 to 1903. The great increase in this period and the considerable changes in sources were discussed, and the variability of the harvests of the separate countries was contrasted with the stability of the world's harvest. The lessening proportion of those engaged in agriculture to the population as a whole was shown by statistics, and certain conclusions as to the increasing economy of wheat production were drawn.

3. *The Importation from Abroad of Foodstuffs producible in Cape Colony. By* E. Nobbs.

The solution of the problem of importation from abroad of foodstuffs producible in the Colony can only be settled by cheapening the modes of production and distribution, so as to enable locally grown articles to compete successfully against the imported article. At present hundreds of thousands of pounds worth of articles are being annually imported which could be readily produced here, and this is a very different matter from importing commodities which we cannot produce.

The idea of this paper is not to analyse the question fully, but merely to render more easily available facts and figures which are at present buried in statistical returns. Owing to the lack of agricultural statistics of the products of the Colony, it is not possible to determine how far the articles herein mentioned can be replaced by colonial production.

The Colony, owing to war, pestilence, and drought, is not in a stable condition, but things are improving more rapidly than is generally thought. The imports of agricultural produce were considerably less in 1904 than in 1903; while those of

certain commodities rose from 1902 to 1903, others fell off. The articles may therefore be classified under three heads:—

1. Those the importation of which rose from 1902 to 1903 and fell again in 1904.
2. Those the importation of which fell from 1902 to 1903 and continued to fall in 1904.
3. Those the importation of which is steadily increasing in volume.

The increase of imports in 1903 over 1902 was probably due to the fact that the natural resources of the Colony had become more depleted and a larger population had to be fed. Imports for 1903 were, therefore, greater than actually needed for that year, and those for 1904 were accordingly less; but the difference in the imports between the two years is hardly to be accounted for by this reason, and is doubtless due to a renewed and even increased activity in farming industries.

Taking the items in Class 1 mentioned above, wheat and flour (taken in terms of wheat) show an increase in 1903 over 1902 and a fall in 1904, but the figures in 1904 considerably exceed those for 1902. This is due in a great measure to the fact that 'rust' has not as yet been overcome, and the probability is that the acreage under wheat will considerably increase when it becomes a safer crop to sow, and there is a large portion of the Colony in which wheat can be profitably grown.

Mealies follow the same curve as wheat, but the imports in 1904 are considerably less than in 1902. The cultivation of this crop presents no difficulties, and with increased transport facilities in the Transkei, where it is chiefly grown, importation may be expected to diminish until it finally ceases altogether.

Mealie meal has a similar trend, but does not fall below the 1902 level; it may, however, be expected to follow the same course as the unground article, though at a slower rate, owing to the industrial conditions of the country.

Barley fluctuates considerably. The crop is notoriously a variable one, and the class of irregularity is one that disorganises the business of merchant and farmer alike. Regular publication of figures showing the actual and prospective yields of harvests would go a long way towards regulating the supply and demand. In view of the use of barley as food for horses and ostriches, and for malting purposes, a larger outlet may be expected for the better qualities of the grain.

The importation of rye fell below the 1902 level in 1904. Normally a certain quantity is exported every year, but this ceased in 1904. Even the immigration of aliens accustomed to eat rye bread hardly accounts for the rise in 1903, and, in view of the rapid decline in 1904, scarcely offers sufficient explanation. Presumably the imported grain was used for fodder, and with oat hay at famine prices in 1903 the rye grown was probably kept where grown for feeding purposes.

The import of beans and peas in 1904 was considerably higher than in 1902. Both these crops can be grown to perfection in the Colony, and in addition enrich the soil instead of exhausting it, as is the case with continuous cereal growing, so that this state of affairs is the more regrettable. As with barley, we exported beans in 1900 at 20*s.* per bag (200 lbs.); now the price is 30*s.* per bag, and we are importing 23,000*l.* worth per annum. The ravages of the weevil have seriously militated against the cultivation of these crops, but this pest has been successfully combated in other countries, and why not here?

The larger importation of grain in 1903, as compared with the year before and the year after, may be attributed to the exhaustion of supplies owing to the war, cessation of agricultural pursuits, the presence of armies in the field, and the influx of non-producing immigrants.

In Class 2 it is to be noted, however, that commodities normally produced in the Colony are being imported to a less degree than formerly, and the importation may perhaps ultimately cease altogether. The importation of fodder was less in 1904 than in 1903, with the remarkable exception of chaff. Importation of

foodstuffs for stock-feeding decreased to about one-half the volume, to which reduction the lower price of oat hay this season probably contributed, together with the increasing production of lucerne and manufacture of compressed fodder.

The local production of bran depends not only on the wheat grown and ground in the Colony, but also upon the quantity of wheat imported for grinding. The falling off of the imports of this article may be put down to the lesser quantity required owing to the cessation of the war.

The imports of fodder would have probably been still less had it not been for the quantities exported to German South-West Africa. It is to be anticipated, therefore, that the importation will still further speedily diminish if favoured with good seasons.

Onions and potatoes were considerably used by the military, hence the large importations; but although the value of imports has fallen, the farmers complain of the difficulty of selling and of the prices obtained, although these supplies can evidently still be imported from abroad at a profit. The difficulties of storage account in a way for this, but are not insuperable.

Cheese fluctuates less, and the increased imports cannot be ascribed to increased production, though with co-operative effort the matter should remedy itself, as cheese-making pays better, gallon for gallon of milk, than butter-making.

The sudden decrease of the imports of beef must be set down to an increased use of the colonial article.

Lard must continue to be imported from America and Australia so long as the importation of pork increases and pigs are regarded as being chiefly valuable as labourers' rations. The decrease in imports may be attributed to the increase of slaughter stock and of butter, having been previously used for want of other forms of fat.

Butter importation is steadily diminishing, though still imported in enormous quantities, thus showing the wide field for the industry in this Colony.

Margarine and other butter substitutes, despite the bad times, show a remarkable falling-off, due to a diminished consumption, as these products are not known to be manufactured in the Colony.

The importation of preserved milk is also on the downward grade. It is still very great, but as facilities increase and the organisation of the milk trade becomes more efficient the use of fresh milk will be made easier and more general. Co-operation may be expected to exert a powerful influence in this direction.

Fresh and dried fruit show a decrease, due wholly to increased local production, as our exports of these articles are also increasing in a satisfactory manner. A feature in the case of dried fruit is the considerable fall in value with but little diminution in the weight. The Colony is at present notoriously overstocked with jams, and there is a steady decline in imports, which may be expected to continue until supply and demand once more equalise.

Honey follows in sympathy with jams, and though the imports are trifling, there should be no necessity to import an article which might easily be entirely produced in the Colony, and even exported.

Salt also shows a falling-off, though it is uncertain whether this is due to the general trade depression or to development of local resources.

In Class 3 there are five commodities the importation of which is steadily increasing in volume.

Chaff is imported in increasing quantities, though every year thousands of tons of straw are left to waste in heaps or are actually burnt. The increasing importation of eggs is a more serious matter, due chiefly to the haphazard methods of collection, the want of organisation, ignorance of the first principles of poultry management, and of the art of packing and marketing.

Dead poultry is another of the items the importations of which are rising, the fact being due to the difficulty experienced by farmers in finding markets and of dealers obtaining ample and steady supplies. The sudden and largely increased importation of pork may be due to the diminished price and to the outbreaks of swine fever in the pig-breeding districts. An improvement may be expected hand in hand with the development of the dairy industry, as there is no more remunera-

tive method of utilising the by-products of butter and cheese making than pig-feeding.

In reviewing the foregoing facts, it is seen that Cape Colony has passed through a trying period as regards its power of supplying its own wants, but that conditions, natural and industrial, are combining to bring matters to their normal condition. The reduction of the inflow of foodstuffs producible in the Colony is most satisfactory, although there is still great room for improvement, and we may look forward to the time when, our markets having been won back, we may export a surplus of many of the articles which at present we import.

JOHANNESBURG.

TUESDAY, AUGUST 29.

The following Papers were read:—

1. *The Progress of Johannesburg. By* STEPHEN COURT.

Johannesburg was founded on September 20, 1886. No town has so quickly reached the population which Johannesburg now has—about 160,000. The municipal area is, roughly, about $81\frac{3}{4}$ square miles, including all land within five miles radius of Market Square. The rateable (capital) value is now nearly forty million pounds. The white birth-rate during the year ended June 30, 1905, was 35·3 per 1,000, and the white death-rate 15·1 per 1,000. The chief causes of death were diarrhœa and dysentery (chiefly infants) and pneumonia.

The Town Council before the war had very inadequate powers. The present Town Council has very wide powers. The franchise, a low one, is confined to British subjects and includes women.

The 'bucket' system is still employed, but it is being replaced by a water-borne sewerage system.

The water supply, formerly in the hands of a company under a concession granted by the late Government, is now entrusted to a board for the whole of the Rand, on which board the mines and local authorities are equally represented.

The distribution of water within the municipality is done by the Town Council. The price of water has already been reduced from a minimum of 12*s*. 6*d*. for the first thousand gallons or less to 6*s*. A special rate is proposed for extensions to new districts within the municipality.

The gas and electric-light undertakings were formerly in the hands of a company, under concessions granted by the late Government, but were acquired by the local authority in 1895. A comprehensive scheme for the supply of electric light at two-thirds of the present charge is now being carried out by the municipality.

The existing tramways only cover $11\frac{3}{4}$ miles of route, and are worked by horses. They were acquired by the town in 1904 from a company which enjoyed a concession granted by the late Government. The municipality is providing electric tramways on a comprehensive scale. The present minimum fare is 3*d*., and this will be reduced to 2*d*. when the electric system is in operation. Owners of some new townships in which a great portion of the land is unsold have agreed to contribute to the cost of extensions of tramway lines to these townships. A special rate is to be levied to meet the cost of extensions to other suburbs where a large number of the plots have been sold.

The railway runs through the town from east to west only, and provides practically no suburban service.

An area, close to the centre of the town, of about 173 acres, most of which was insanitary, and which was so laid out as to confine westward traffic to one street, has been expropriated by the Town Council. The area is being drained and the land re-laid out in large blocks. Two of the principal thoroughfares to the west will be carried through the area.

Two parks of about 274 acres and 200 acres respectively have been given to the town within the last three years.

The market is owned by a company under a concession granted by the late Government. The Town Council contemplates the establishment of a municipal market.

The public library is a subscription one, the reading room only being free, and is managed by a committee mostly composed of subscribers, but on which the Town Council is represented, as it makes an annual grant.

The only poor-relief duty imposed on the municipality is that of burying dead paupers, but the Town Council contributes to local charitable institutions.

The hospital is managed by a board nominated by the Government, which contributes about two-thirds of the total revenue. Both paying and non-paying patients are admitted.

The police are under Government control.

Primary education is provided for by the Government, and is free, but not compulsory. The Government also maintains fee-paying secondary schools, and a technical institute, to the funds of which the Government contributes, has been established.

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2. *A Search for General Principles concerning the Relation between Central and Local Government Finance. By* EDWIN CANNAN, *M.A., LL.D.*

Why should there be any local government finance? Why not have a common purse for the whole country? 'Historical reasons' are not sufficient explanation, still less sufficient justification. The separation of local finance is necessary, in the first place, to secure efficient administration, which is impossible without the rivalry and variety which result from the existence of large numbers of independent administrative bodies. Secondly, it is necessary in order to secure that the capital of the country is invested in the best way and the population settled in the most suitable places.

Without it the central Government would practically have to decide every question concerning the economic development of the country. Under present circumstances no Government could do this as well as it is done by allowing localities freedom to spend or not to spend as they see fit; even if a Government had the will and the wisdom necessary, which is impossible, it would be prevented by the fact that the economically correct course would often be flagrantly unjust in the absence of local taxation.

Local governments, while socialistic as regards the persons within their areas, are individualistic as regards the central Government. Much of their expenditure is of the same nature as the ordinary expenditure of an individual, while some resembles that part of an individual's expenditure which goes in taxation. In regard to both the treatment of the locality should be the same as that of the individual; *i.e.*, the part resembling normal expenditure should be left entirely alone, and, in regard to the other part, the State should endeavour to combine economy and the accepted ideas of equitable taxation as well as possible. To attain this end subsidies from central to local exchequers will sometimes be necessary. The exact basis on which they should be given must be worked out in each case with regard to the particular circumstances.

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3. *The Rise and the Growth of the Protection of Industrial Property in the Transvaal. By* JOHN A. BUCKNILL, *M.A.*

The value of those rights included in the phrase 'industrial property' has in these times of rapid scientific advance and keen commercial competition increased with quick strides. Any civilised community of modern days finds, soon after it has assumed a fairly settled existence, that its members desire legal or statutory assistance for the determination and preservation of various more or less personal privileges which, by the test of time and practice, have been found in other

politics desirable, and indeed necessary, for the best maintenance and progress of national welfare.

In a young State the first, perhaps, of these aspirations may be found in the desire of the merchant to distinguish his own goods from those of others, and from this wish has, in older countries, after many, many years, arisen statute law of somewhat simple character safely capable, with slight modification, of being adopted by the Legislature of a new country. To the commercial element, then, are due the rights enjoyed in the use of trade-marks, possibly the most important branch, from a general public point of view, of those privileges which are referred to in this paper. Normally, at a slightly later stage of development, and whenever there is any marked forward movement in the industrial life of the country, individual invention is brought into prominence; whilst for the exploitation of enterprises larger or more hazardous than can conveniently or safely be undertaken by any single person, mutual co-operation and its attendant liabilities invariably demand the attention and assistance of the governing authorities. The grant of patents encourages and protects the initiators of useful novel inventions, whilst the limitation of the pecuniary liability of those engaged in joint endeavours to found an industry or discover national resources allows the more cautious citizen to engage a definite proportion of his assets in a promising, although speculative, adventure.

At a still later stage in the ordinary course of the life of a new country is shown the last branch of this group of industrial rights—artistic and literary productions—not always, but usually, a sign of the presence of a considerable development in national thought, and certainly of advanced erudition. This most desirable fine flower, 'culture,' is protected by what is usually termed 'copyright.'

The Transvaal presents an unusually instructive and interesting study of a civilised community of very recent growth which has by its enactments, with considerable skill and adroitness, adapted itself to meet not the normal statutory development of a State beset by unexpected circumstances, but conditions which were presented to it hastily, almost without its own knowledge, and entirely beyond its own control.

As the South African Republic the Transvaal had really been in existence as an independent State for only about twelve years prior to the British annexation in 1877; at that date it was undoubtedly in a temporarily moribund condition; but as early as 1874 its Legislature had been capable of passing two laws relating to companies which, whilst they may not stand criticism of the knowledge of the world obtained after thirty years' experience, were of a useful and most important nature, and, it may be added, are still on the Statute-book of the Colony. Law No. 5 of 1874 limited personal liability for locally formed companies under conditions perhaps more salutary even than those at present in force in England; whilst Law No. 6 of the same year welcomed the presence of and offered some, though somewhat vague, protection to associations initiated outside the country but intending to operate locally. That the earliest modern discoveries of gold in the Transvaal were responsible for the passage of these laws there is no doubt, and the causes which led up to these and similar enactments form in themselves an interesting study. The law relating to the advantage offered to co-operative enterprise does not really fall within the purview of the rights covered by the phrase 'protection of industrial property,' but the excuse for its introduction into this paper is that the various enactments, amplified as they have been at various times, are administered in this Colony by the same sub-department which deals with patents and trade-marks.

The proof of the value of auriferous deposits in the country, the rush to Barberton in 1886, and the discovery of the Rand in 1887, were directly responsible for the almost immediate passage of the first Patent Law in 1887, and, curiously enough, in the same year was passed the first copyright enactment. The attitude of the Volksraad at the introduction of the Patent Law, the provisions of which were, undoubtedly, altogether strange to the majority of the members of the Assembly, was of an enlightened character, and it is a matter of regret that in the later Acts of 1897 and 1898 the idea of increased taxation upon

the goldfields—the chief source of revenue and almost the only fountain of invention and material progress—should have harassed the inventor and crushed ingenuity by the imposition of enormous renewal fees and a legal procedure alike of a detrimental and deterrent character to the individual discoverer of a new art or process. That a Patent Law was required there is no doubt, and advantage of its terms were largely taken by the public; but an Ordinance relating to copyright was at that time premature, and, indeed, even at the present time its provisions are very seldom brought into operation. Far more interesting, however, to the student is the presence before, with, and after the passage of these Patent Laws of personal rights locally known as 'concessions,' but which were in fact grants, somewhat of the character of those swept away in 1624 in England by the Statute of Monopolies (21 Jac. I., cap. 3). Issued mainly under the pretext of assisting local enterprise and encouraging local industry, and not—as were the monopolies granted by the English kings—openly given in exchange for personal pecuniary benefit and as a royal prerogative, these concessions were, it is now admitted, mainly obtainable by a judicious approach to those who had the power to give legal effect to these grants. Although not all exclusive monopolies, this vicious form of protection embraced such important subjects as liquor, explosives, railways, iron, sugar, wool, bricks, earthenware, paper, candles, soap, calcium carbide, oil, matches, jam, cocoa, and bottles. It cannot be said for one moment that these concessions did not interfere with the more legitimate patents for inventions; it was a practical impossibility for many years for any person to obtain a patent for explosives in the country owing to the explosives monopoly, and indeed, on at least one occasion, a proposed concession and an issued patent practically came into direct conflict.

Last, where in theory it should be first, appears in 1892 the Trade-Mark Law, a measure due, doubtless, directly to the growth of population and the expanding condition of what were but a few years before mere mining camps, and indirectly to the decision in the case of Rose & Co. *v.* Miller in 1891. With the later development of these laws it is not necessary to deal in this abstract, nor, indeed, have the later enactments the same interest as those passed by the old Raad. It will perhaps suffice to say that a marked indication of restored confidence since the last change of Government is shown by the enormous increase which has taken place in the application for the various rights which are included in the title 'industrial property.'

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4. *The Practice and Theory of Dumping.* *By* W. J. CLARKSON.

This was a discussion of the practice and theory of dumping in the commercial sense of the word. After describing the practice, which it was pointed out includes only the case of selling commodities abroad at a price below the cost of production, and the converse, which is the purchasing of such goods, it was shown how a high protective tariff, as in Germany, may give producers a monopoly of their own market. This leads to those combinations of producers known as trusts or cartels, whose primary object is to raise the price of the commodities they produce, to the disadvantage of the rest of the country. Workshops and factories are equipped for enormous outputs, in order to minimise the cost of production, which frequently leads to surplus production. This surplus cannot be disposed of at home, owing to the stringent regulations of the trust regarding selling price, and must therefore be sold abroad at a loss. The evil effects of this practice upon the resource of the country were discussed, and the high price of iron and steel in Germany was instanced, where manufacturers of the finished goods are at a great disadvantage when competing both for home and foreign trade.

The economic effect upon the country purchasing dumped goods was described. Low-priced importations, it was argued, increase the productiveness of the importing country and allow of a greater return to capital and labour. Greater opportunities occur for competing successfully for the world's trade. It is doubtful whether any industry—in the United Kingdom, for example—is, or can become,

in a declining condition through the competition of dumped goods from abroad. It is asserted that the relative amount of goods dumped into Great Britain, compared with the volume of the home production of similar goods, is an almost negligible percentage; which might be expected, considering that dumping involves such losses to those having recourse to it that its extent is bound to be, comparatively speaking, very limited.

The full effect of dumping is brought out by reflecting upon the train of consequences which would be set up if an international combination against England were established by the other great producing nations for the purpose of dumping into England all those classes of commodities which she now produces, with the view of destroying her industries. The conclusion is that the balance of the advantages of dumping rests entirely in favour of the purchasing country.

WEDNESDAY, AUGUST 30.

The following Papers were read:—

1. *The Cost of Living on the Rand.* *By* A. Aiken.

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2. *The Study of Economics in South Africa.* *By* A. S. Kidd.

The object of this paper was to show how little encouragement has been given to the study of economics in South Africa in the past, and at the same time to call attention to some of the many interesting topics peculiar to South African life which deserve investigation. Economics has been, comparatively speaking, neglected by the university and colleges of this country. Our civil servants and politicians have had no training in the science. Private students have been few and their output small. The South African Association for the Advancement of Science has in a way laid the foundation-stone of a South African School of Economics, but there is a great need for encouragement and development. There are, in addition to the most obvious economic problems of South Africa, many others of an interesting nature—for example, the future of the native artisan, the local markets, and the cost of living in various localities.

Two subjects of great interest in Cape Colony are the history of taxation and the history of our imports and exports, both of which subjects would repay careful investigation. Materials for the study of such questions are, unfortunately, inaccessible to many would-be students; nevertheless, much might be done in certain centres. As regards the study of statistics in general, the student has to face many difficulties, and official publications have in the past been somewhat unsatisfactory in method. The establishment of an Inter-Colonial Bureau of Trade Statistics is in sight, the creation of which will probably bring about an improvement. Some of the social problems that are most pressing in the homelands are here conspicuous by their absence; others, however, will have to be faced in these colonies. The visit of the British Association will, it is hoped, among its other effects, produce a greater interest in economics in South Africa.

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3. *What is Credit?* *By* Francis W. Buxton, *M.A.*

The author feared that such an abstract question was hardly suitable to Johannesburg, but under the circumstances had no option.

The 'loan fund of the State,' as Bagehot calls it, used formerly to consist of cattle, and not of capital, as now understood. 'Cattle' and 'capital' are etymologically the same word. Sir H. Maine in 'Early Institutions' describes a condition of Irish society which was based on the lending by the chief of his herd of cattle to his villeins for services rendered. By 'taking stock' the free Irish tribesman became the vassal of his chief.

Demosthenes recognised the division of every community into 'lenders' and 'borrowers.' In these days Lombard Street collects the savings of private individuals and lends them again. Thus the loan fund, collected in the hands of bankers, is lent out immediately and supports all trades, even all States.

Bankers live by lending, and we may be sure borrowers would not borrow unless they could use the money profitably.

'Lombard Street' is the most highly developed instrument for lending the loan fund wisely and prudently. It lends instantaneously to the trades most requiring money, *i.e.*, to those who can use it most profitably and can give the best security. All the Lombard Street transactions are in paper, not in gold. Bills of exchange are the banker's medium.

J. S. Mill on 'credit.'—We may divide 'credit' into three classes: (1) Bank-notes, cheques, &c., which rest on a solid metallic basis; (2) commercial credits, on a tangible basis of value, goods or securities which are realisable; and (3) personal and blank credits, which rest on a potential or expected basis of value.'

Credit is potential capital.

FRIDAY, SEPTEMBER 1.

The following Papers were read:—

1. *Some Aspects of the Native Question. By* HOWARD PIM.

No single native policy is accepted throughout South Africa as adequate and sound. This is the natural consequence of—

(*a*) The short time during which organised white communities have been in contact with the native races.

(*b*) Differences of custom, training, and character among the native tribes themselves.

It is therefore still useful to examine if native custom and methods of government afford us any indication of—

(*a*) The tendencies which exist among them.
(*b*) The lines of least resistance to their education.

Four large factors in native life were therefore considered:—

(*a*) Polygamy.
(*b*) Tribal system.
(*c*) Relation to the land.
(*d*) Education.

These questions were examined in the first instance as if the Kaffir could develop in this country without the interference of the white races, but this is not the case; his development must directly affect the white races with whom he is in contact, and be directly affected by them.

The probable results of intercourse between the white and native races is, therefore, an integral part of the native question, and by no means the least difficult.

The South African evidence as to this is not only scanty and incomplete, but has not yet been systematised.

It is therefore necessary to look elsewhere; and although the negro question in the United States presents obvious differences to our South African case, the relations there between whites and negroes, and especially the tendencies manifested in the development of these relations since the slaves were freed, are of great importance, and probably of great value.

The author examined these tendencies, and suggested some conclusions there-

from which, it was submitted, are applicable to the problems as they state themselves in South Africa.

These conclusions are:—

(*a*) That to give the native political power is premature.

(*b*) That the tendency of race feeling is towards segregation.

(*c*) That the greatest benefit each race can confer upon the other is to cease to form part of the other's social system—that is, not to become politically independent, but to become socially independent.

(*d*) That the evidence points to a wise use of the reserve system as the means best adapted to attain this end, and that scattering natives promiscuously among a white population will not conduce thereto.

(*e*) That satisfactory results can only be attained by keeping the best of the natives in touch with the best of the whites, and that this involves governing them on what may be called paternal lines.

(*f*) That powers of self-government should be granted to a limited extent, varying with the circumstances of each particular tribe or district, and confined to native affairs.

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2. *Some Statistics of the Mineral Industry of the Transvaal. By* A. C. Sutherland, *M.A.*

The following statistics dealing with the mineral industry of the Transvaal are based upon official figures appearing in reports of the Government Mining Engineer. In them the term 'oz.' is used as meaning a 'fine oz.' (valued in the case of gold at 4·24773*l.*), the term 'ton' as meaning 2,000 lb., and the term 'works' as meaning any metallurgical, chemical, brickmaking, pottery, or lime works, or places where machinery is erected.

Output.—The mineral output of the Transvaal during 1904 consisted of gold, diamonds, coal, silver, chemicals, manures, paints, disinfectants, and a small quantity of metals other than gold produced at metallurgical and chemical works, stone, lime, bricks, pottery, &c., the total value being 18,428,210*l.*, of which gold, diamonds and coal accounted for 98·02 per cent., and gold alone for 86·98 per cent. The output of gold was 3,773,517 oz., valued at 16,628,883*l.*, of which 62·77 per cent. was recovered from mills, 35·96 per cent. from chemical treatment on crushing mines, 1·11 per cent. from metallurgical and chemical works, 0·10 per cent. from tailings syndicates and non-crushing mines, 0·02 per cent. from alluvial workings, and 0·04 per cent. from other sources. The total tonnage of ore milled was 8,409,447, and the yield per ton milled, based on the officially declared output, which does not include gold contained in by-products not treated at the mines, was 8·861 dwt., of which 5·634 dwt. was obtained from mills and 3·227 dwt. from chemical treatment on the crushing mines. Including the gold estimated to be contained in products sold, the total yield per ton milled was 8·965 dwt. The number of producing mines increased during the year from 68 to 81 and from 56 to 66 in the Transvaal and in the Witwatersrand area respectively. The number of stamps running increased during the year from 4,705 in January to 5,850 in December, and was theoretically equivalent to 4,757 stamps running without cessation throughout the whole year. The average number of tons crushed per stamp per day was 4·83. The number of stamps erected on June 30, 1904, was 8,856. During 1903 the Transvaal's output of gold was 2,972,897 oz., amounting to 18·7 per cent. of the output of the world.

The output of diamonds amounted to 884,331 carats, valued at 1,150,873*l.*, of which value the stones found at the Premier diamond mine accounted for 95·60 per cent.

2,409,003 tons of coal were sold by collieries, with a value at the pit's mouth of 883,891*l.*; 46·39 per cent. of this coal was mined in the Springs-Brakpan area, 45·06 per cent. in the Middelburg area, and 8·55 per cent. in the remainder of the Transvaal.

All the silver was contained in the gold bullion, and was estimated to amount

to 416,262 oz., valued at 45,319*l.* Metallurgical and chemical works produced, in addition to gold, a small quantity of other metals, chemicals, manures, disinfectants, paints, &c., to the value of 20,045*l.* Stone, lime, bricks, pottery, &c., were produced at works to the value of 299,199*l.*

During 1904 the following development took place in gold mines: main shaft sinking, 32,202 ft.; main drives and cross-cuts, 312,878 ft.; other development, 125,019 ft.; while on coal mines 1,857 ft. were sunk and 210,605 ft. were driven.

Labour.—The average number of persons at work on mines and works during the last six months of 1904 was 110,724, comprising 15,505 whites, 85,768 coloured, and 9,451 Chinese. 86·66 per cent. of these persons were engaged in the production of gold, 7·79 per cent. in the production of coal, 2·72 per cent. in the production of diamonds, and 2·83 per cent. on other mines and work. The average number of persons at work for the same period on the gold mines of the Witwatersrand was 89,106, comprising 13,683 whites, 65,972 coloured, and 9,451 Chinese. The increase in the number of persons at work during this period was a large one, the average number at work on the Witwatersrand gold mines for the month of December, 1904, being 103,511, comprising 14,166 whites, 70,512 coloured, and 18,833 Chinese. The number of persons at work on the Witwatersrand gold mines in July, 1899, the only month of that year for which complete figures could be found in the records of the late Government, was 103,669, comprising 12,530 whites and 91,139 coloured. During the half-year ending December 31, 1904, of the total number of coloured and Chinese employed, the average percentages at work were 92·68 per cent. and 85·05 per cent. respectively.

Wages.—The total amount paid during 1904 in salaries and wages on the mines and works was 7,708,322*l.*, of which 64·74 per cent. was received by white men, 34·19 per cent. by coloured persons, and 1·07 per cent. by Chinese.

The average yearly salary and wages per head were:—

487*l.* 5*s.* 6*d.* for the staff,
319*l.* 12*s.* 8*d.* for white workmen,
30*l.* 19*s.* 11*d.* for coloured persons,
17*l.* 10*s.* 5*d.* for Chinese.

The amounts expended on food, medicines, and other supplies for coloured and Chinese employes, which were received by them in addition to their wages, were 470,994*l.* and 51,117*l.*, averaging 8*s.* 9·5*d.* and 15*s.* 4*d.* per head per month respectively.

Accidents.—During the half-year ending December 31, 1904, 502 separate accidents occurred on mines and works, resulting in 620 casualties, there being 206 persons killed and 414 injured. The principal causes of these casualties were explosions and falls of ground, which accounted for 21·29 per cent. and 20·65 per cent. of the total respectively The death-rates per annum from accidents for the years ending June 30, 1902, 1903, and 1904 were, respectively, 3·3271, 4·0368, and 4·7498 per 1,000 persons at work.

Stores—The total value of the stores consumed by the mines and works during the year 1904 was 6,692,114*l.*, of which the gold mines of the Transvaal and of the Witwatersrand accounted for 92·44 per cent. and 87·98 per cent. respectively. The three principal items were: Machinery and machine tools to the value of 1,057,878*l.*; coal, 952,558*l.*; and explosives, 759,151*l.* Of the stores consumed by the mines during the year ending June 30, 1904, only 4·204 per cent. was imported direct by the mining companies.

Explosives.—The value of the explosives consumed by the mines and works during 1904 was 759,151*l.*, of which blasting gelatine and gelignite accounted for 74·48 per cent. and 20·80 per cent. respectively. The value of detonators consumed was 24,958*l.*

Machinery.—The total value on June 30, 1904, of the machinery, plant, and buildings on all mines and metallurgical and chemical works was estimated at 19,570,120*l.*, of which the gold mines accounted for 95·51 per cent. During the year ending June 30, 1904, the amount of 1,279,847*l.* was expended on sundry items of machinery and 'spares,' and 1,951,838*l.* on equipment of new mines and

the extension of the plants of other mines. The three chief items were plant and buildings, reduction plant excluding engines, and treatment plant including furnaces, &c., the values of which form respectively 19·47 per cent., 15·56 per cent., and 13·80 per cent. of the total.

The number of prime movers on June 30, 1904, was 1,516, with an indicated horse-power of 211,319, and the total number of boilers was 1,977.

The aggregate horse-power of the intermediate machinery and of the driven machinery was, respectively, 84,738 and 185,871.

Water Conservation.—The estimated maximum storage capacity on June 30, 1904, of the dams and reservoirs on gold, diamond, and coal mines, and on metallurgical and chemical works, was 4,150,000,000 gallons, while the estimated quantity of water stored in them on that date was 3,607,243,300 gallons. There was also an additional quantity of 470,745,500 gallons stored in pans and wells.

Capital.—The nominal capital on June 30, 1904, of 339 mining companies from whom returns were received by the Department of Mines was 111,416,102*l.*, of which 98,891,499*l.* had been issued, leaving 12,524,603*l.* in reserve. During the year ending June 30, 1904, 37 of these mining companies, with an issued capital of 17,412,034*l.*, paid dividends amounting to 3,835,565*l.*, equal to a rate of 22·03 per cent. The total amount paid in dividends from 1887 to 1904, inclusive, by gold mines of the Witwatersrand was 28,331,906*l.*

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3. *The Development and Working of Railways in the Colony of Natal.* *By* Sir David Hunter, *K.C.M.G.*

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4. *The Colonial Lands of Natal.* *By* Robert À Ababrelton.

Natal has been a British possession for more than half a century. Natal proper contains approximately 12,000,000 acres. It is of importance to notice the manner in which that land has been dealt with by the Colony. Zululand and the 'Northern Territories' (till lately forming part of the Transvaal), having lately been annexed to Natal, are excluded from consideration in this paper.

Prior to occupation by Europeans, different tribes of Bantus 'squatted' on the land, cultivating small plots here and there, removing to other plots when the soil became exhausted or more suitable spots were found, or the squatters were ousted by a superior tribe. The cultivation was very poor, principally by the women. It is reported that, owing to Tshaka's raids from Zululand, the Bantus in Natal proper were almost exterminated, only about thirty remaining between the Zululand border and the Umzimkulu. Individual ownership of land was unknown. Tribal lands were held by the chief on behalf of his tribe.

The Dutch, under Retief, entered Natal in 1837. At that time, and for some years later, it was customary for the Dutch settler to claim as his 'farm' as much land as he could ride round between sunrise and sunset.

In South Africa the word 'farm' is used for any extent of land under one ownership, whether cultivated or uncultivated.

The British occupation, at first only of what is now the town of Durban and the surrounding country, took place in 1838–1839.

The Dutch Republic of Natalia, which practically meant the remaining portion of Natal proper, with its capital at Pietermaritzburg, was proclaimed on December 24, 1839. With the exception of Durban it exercised jurisdiction over all Natal proper.

Natal as a whole became a British colony on May 10, 1843. It was annexed to Cape Colony in 1845. At this time all the lands of the Colony were considered to belong to the Crown, but as they were dealt with by the Colonial Government, with very little interference from the authorities in England, they may fairly be called the 'colonial' lands of Natal.

Grants of these colonial lands were made from time to time to Boer farmers, to towns and villages, and for native or mission purposes, &c. The Boer farmers,

who were unfavourable to the British occupation, are said to have encountered considerable difficulty in getting their claims allowed and confirmed by the necessary 'grant.' Those Boers who had practically declared themselves independent of British rule, fearing dispossession, deserted their farms in considerable numbers during 1846-1847.

Grants were made to British subjects on quit-rent tenure; but to stop the exodus of Boers the Dutch were promised permanent titles to their farms, not exceeding 4,000 acres each, with the remission of the quit-rent for the first three years. In that way 245,000 acres were alienated; whilst 3,150,000 acres were alienated to British subjects on quit-rent tenure, with power to convert into freehold in each case.

Natal became a separate colony in the year 1856.

Then came, in 1856, the 'military service grants,' the grantee undertaking to keep a horse and gun, with the necessary ammunition, &c. Under these grants 65,000 acres were alienated for ever, the 'military service' obligation soon falling into desuetude.

This was followed, in 1857, by grants of quit-rent farms, with a fine for 'non-occupation' of four times the amount of the quit-rent per acre, in addition to the quit-rent itself. This 'non-occupation fine' was largely evaded or not enforced; 1,320,000 acres were alienated in this way. In other ways not specified 655,000 acres were granted in freehold.

In 1880 the ten-years' purchase system was instituted, afterwards altered to the twenty-years' purchase system, which still obtains. Theoretically, the purchase system should be very beneficial to the Colony. The lands are sold in freehold by public auction at an upset price or 'reserve' of 10*s.* per acre, the purchase price being spread over the period mentioned in equal instalments. Beneficial occupation is insisted upon on paper. Practically, by arrangement between intending purchasers, and by the non-enforcement of the occupation clause, these purchase systems have largely failed in their object. In consequence of the inquiries of the Lands Commissions in 1901, it was discovered that there had never been a case in which such lands had been resumed for default in fulfilling the terms of the occupation condition. Under these systems 2,590,000 acres have been alienated.

Approximately, there only remain about 1,000,000 acres of colonial lands unalienated, which the Surveyor-General considers to be mainly in the least accessible districts of the Colony. This means, in practice, that the most valuable asset of the Colony has been alienated for ever.

It should be mentioned that $2\frac{1}{2}$ millions of acres are held in trust for the natives for ever; 170,000 acres were granted for missionary purposes; 16,600 acres were granted for educational purposes, and 135,000 acres were set apart for towns and villages.

The alienation of these colonial lands has not been entirely without benefit to the Colony. That would be impossible. It is beneficial, in a sense, if lands are taken up under *any* conditions. But through parting with (or 'giving away,' as the Lands Commissioners termed it) the Crown lands of the Colony in the manner indicated, Natal must now look more to its other resources for its future prosperity.

If the proceeds of the sale of these colonial lands had been set apart to form a fund for future use in connection with land settlement, instead of being thrown into general revenue, the prospects of white occupation would be very different to those at present existing.

In 1902 the Lands Commission recommended that this should be done in the case of all lands in process of alienation then or in the future; but, so far as the author is aware, this recommendation has not been carried out.

The great object of the sale of the colonial lands was their beneficial occupation by persons of European descent, and the increase of the white population of the Colony. It has been a common practice to approach the Government, through members of the Legislature or high officials, for relaxation from occupation conditions. No case came before the Commission where such an application was met by the suggestion that the land should be resumed by the Government. Such an

idea never appears to have entered the minds of those concerned. The report of the Commission states: 'Titles have been acquired by little or absolutely no occupation. The beneficial occupation condition has debarred numbers of persons from purchasing Crown lands. Others, less scrupulous, have purchased, and ignored the conditions, and acquired the titles.'

5. *The State in relation to Agriculture in South Africa.* *By* F. B. Smith.

From the earliest times the Governments of States or communities have interested themselves in agriculture, for the obvious reason that their very existence to a large extent depended upon that art or industry. Until lately State efforts have been mainly directed towards protecting the farmer from physical interference, and towards imposing protective duties or giving bounties on certain products. Various enlightened Administrations have from time to time introduced new varieties of stock and crops, and have endeavoured to educate the farmers and improve their methods; but the work has to a great extent been dependent upon the bent of individuals, and has not been consistently pursued by the States concerned.

Owing to changed conditions and to keen competition the subject of agricultural administration has become a very important one, and the most enterprising countries in both hemispheres are straining every nerve to so protect, educate, and organise the farmers that their labours may be attended with the greatest advantage, and not only may their own lands be supplied with cheap food, but the farmers may obtain their share of the markets of the world.

Until recently South Africa was entirely dependent upon agriculture; and having regard to the fact that Cape Colony was first occupied by the Dutch, who are notoriously great farmers, as far back as 1652, one might have expected that agriculture and agricultural administration would have attained a high state of development; but this is not so. The reasons for this lack of progress are due chiefly to the isolation of South Africa and of the individual farmers therein, to the dispositions of the people, the lack of markets, absence of competition, the attractions of the chase, and other factors.

Shortly before the late war there was a great awakening as regards agriculture, but though large sums of money were expended in endeavouring to assist it, the efforts were not very well organised or wisely directed.

Since the late war the various colonies have been endeavouring to put their houses in order. The present affords an excellent opportunity for so doing, and it is of the utmost importance that every advantage should be taken of it, so that matters may be placed upon a proper footing once and for all and the discredit of a false start avoided.

The problems which confront the various Administrations are many and difficult, and must be dealt with in a radical manner.

It is the duty of the State to endeavour to remove the disabilities from which farmers suffer as regards diseases of animals and plants, and other matters; to increase and cheapen production; to protect the farmers from fraud, from unfair competition and taxation; to organise them; to educate them; to open up new markets and to develop new industries; to improve and cheapen communication and transport; to promote forestry and irrigation works.

SECTION G.—ENGINEERING.

PRESIDENT OF THE SECTION—Colonel Sir COLIN SCOTT MONCRIEFF, G.C.S.I., K.C.M.G., R.E.

The President delivered the following Address at Johannesburg on Tuesday, August 29:—

SCIENCE has been defined as the medium through which the knowledge of the few can be rendered available to the many; and among the first to avail himself of this knowledge is the engineer. He has created a young science, the offspring, as it were, of the older sciences, for without them engineering could have no existence.

The astronomer, gazing through long ages at the heavens and laying down the courses of the stars, has taught the engineer where to find his place on the earth's surface.

The geologist has taught him where he may find the stones and the minerals which he requires, where he may count on firm rock beneath the soil to build on, where he may be certain he will find none.

The chemist has taught him of the subtle gases and fluids which fill all space, and has shown him how they may be transformed and transfused for his purposes.

The botanist has taught him the properties of all trees and plants, 'from the cedar tree that is in Lebanon even unto the hyssop that springeth out of the wall.'

And all this knowledge would be as nothing to the engineer had he not reaped the fruits of that most severe of all pure and noble sciences—the science of numbers and dimensions, of lines and curves and spaces, of surfaces and solids—the science of mathematics.

Were I to attempt in the course of a single address to touch on all the many branches of engineering, I could do no more than repeat a number of platitudes, which you know at least as well as I do. You would probably have fallen asleep before I was half finished, and it would be the best thing you could do. I think, then, that it will be better to select one branch, a branch on which comparatively little has been written, which has, I understand, a special interest for South Africa, and which has occupied the best years of my life in India, Southern Europe, Central Asia, and Egypt—I mean the science of irrigation. My subject is water—living, life-giving water. It can surely never be a dry subject; but we all know that with the best text to preach on the preacher may be as dry as dust.

Irrigation: What it Means.

Irrigation may be defined as the artificial application of water to land for the purposes of agriculture. It is, then, precisely the opposite of drainage, which is the artificial removal of water from lands which have become saturated, to the detriment of agriculture. A drain, like a river, goes on increasing as affluents join it. An irrigation channel goes on diminishing as water is drawn off it.

Later on I shall show you how good irrigation should always be accompanied by drainage.

In lands where there is abundant rainfall, and where it falls at the right season of the year for the crop which it is intended to raise, there is evidently no need of irrigation. But it often happens that the soil and the climate are adapted for the cultivation of a more valuable crop than that which is actually raised, because the rain does not fall just when it is wanted, and there we must take to artificial measures.

In other lands there is so little rain that it is practically valueless for agriculture, and there are but two alternatives—irrigation or desert. It is in countries like these that irrigation has its highest triumph; nor are such lands always to be pitied or despised. The rainfall in Cairo is on an average 1·4 inch per annum, yet lands purely agricultural are sold in the neighbourhood as high as 150*l.* an acre.

This denotes a fertility perhaps unequalled in the case of any cultivation depending on rain alone, and this in spite of the fact that the Egyptian cultivator is in many respects very backward. The explanation is not far to seek. All rivers in flood carry along much more than water. Some carry alluvial matter. Some carry fine sand. Generally the deposit is a mixture of the two. I have never heard of any river that approached the Nile in the fertilising nature of the matter borne on its annual floods; with the result that the plains of Egypt have gone on through all ages, with the very minimum of help from foreign manures, yielding magnificent crops and never losing their fertility. Other rivers bring down little but barren sand, and any means of keeping it off the fields should be employed.

Primitive Means of Irrigation.

The earliest and simplest form of irrigation is effected by raising water from a lake, river, or well, and pouring it over the land. The water may be raised by any mechanical power, from the brawny arms of the peasant to the newest pattern of pump. The earliest Egyptian sculptures show water being raised by a bucket attached to one end of a long pole, turning on an axis with a heavy counterpoise at the other end. In Egypt this is termed a *shadoof*, and to this day, all along the Nile banks, from morning to night, brown-skinned peasants may be seen watering their fields in precisely this way. Tier above tier they ply their work so as to raise water 15 or 16 feet on to their land. By this simple contrivance it is not possible to keep more than about 4 acres watered by one *shadoof*, so you may imagine what an army are required to irrigate a large surface. Another method, largely used by the natives of Northern India, is the shallow bucket suspended between two strings, held by men who thus bale up the water. A step higher is the water-wheel, with buckets or pots on an endless chain around it, worked by one or a pair of bullocks. This is a very ordinary method of raising the water throughout the East, where the water-wheel is of the rudest wooden construction and the pots are of rough earthenware. Yet another method of water-raising is very common in India from wells where the spring level may be as deep as 100 feet or more. A large leathern bag is let down the well by a rope passing over a pulley and raised by a pair of bullocks, which haul the bag up as they run down a slope the depth of the well. An industrious farmer with a good well and three pairs of good bullocks can keep as much as 12 acres irrigated in Northern India, although the average is much less there. The average cost of a masonry well in India varies from 20*l.* to 40*l.*, according to the depth required. But it is obvious that in many places the geological features of the country are such that well-sinking is impracticable. The most favourable conditions are found in the broad alluvial plains of a deltaic river, the subsoil of which may be counted on as containing a constant supply of water.

Pumps and Windmills.

All these are the primitive water-raising contrivances of the East. Egypt has of late been more in touch with Western civilisation, and since its cotton

and sugar-cane crops yield from 6*l.* to 8*l.*, or even 10*l.* per acre, the well-to-do farmer can easily afford a centrifugal pump worked by steam power. Of these there are now many hundreds, fixed or portable, working on the Nile banks in Egypt. Where wind can be counted on the windmill is a very useful and cheap means of raising water. But everything depends on the force and the reliability of the wind. In the dry Western States of America wind power is largely used for pumping. It is found that this power is of little use if its velocity is not at least six miles per hour. (The mean force of the wind throughout the whole United States is eight miles per hour.) Every windmill, moreover, should discharge its water into a tank. It is evident that irrigation cannot go on without cessation day and night, and it may be that the mill is pumping its best just when irrigation is least wanted. The water should, therefore, be stored till required. In America it is found that pumping by wind power is about two-thirds of the cost of steam power. With a reservoir 5 to 15 acres may be kept irrigated by a windmill. Without a reservoir 3 acres is as much as should be counted on. Windmills attached to wells from 30 to 150 feet deep cost from 30*l.* to 70*l.*

Artesian Wells.

Up to now the Artesian well cannot be counted on as of great value for irrigation. In the State of California there are said to be 8,097 Artesian wells, of a mean depth of 210 feet, discharge 0·12 cubic feet per second, and original cost on an average 50*l.* Thirteen acres per well is a large outturn.

In Algeria the French have bored more than 800 Artesian wells, with a mean depth of 142 feet, and they are said to irrigate 50,000 acres. But this is scattered over a large area. Otherwise, the gathering ground would probably yield a much smaller supply to each well than it now has. In Queensland Artesian wells are largely used for the water-supply of cattle stations, but not for irrigation.

Well Irrigation.

It is evident that where water has to be raised on to the field there is an outlay of human or mechanical power which may be saved if it can be brought to flow over the fields by gravitation. But there is one practical advantage in irrigating with the water raised from one's own well or from a river. It is in the farmer's own hands. He can work his pump and flood his lands when he thinks best. He is independent of his neighbours, and can have no disputes with them as to when he may be able to get water and when it may be denied to him. In Eastern countries, where corruption is rife among the lower subordinates of Government, the farmer who sticks to his well knows that he will not require to bribe anyone; and so it is that in India about 13 millions of acres, or 30 per cent. of the whole annual irrigation, is effected by wells. Government may see fit to make advances to enable the farmer to find his water and to purchase the machinery for raising it; or joint-stock companies may be formed with the same object. Beyond this all is in the hands of the landowner himself.

Canal Irrigation.

Irrigation on a large scale is best effected by diverting water from a river or lake into an artificial channel, and thence on to the fields. If the water surface of a river has a slope of 2 feet per mile, and a canal be drawn from it with a surface slope of 1 foot per mile, it is evident that at the end of a mile the water in the canal will be 1 foot higher than that in the river; and if the water in the river is 10 feet below the plain, at the end of 10 miles the water in the canal will be flush with the plain, and henceforth irrigation can be effected by simple gravitation.

When there is no question of fertilising deposit, and only pure water is to be had, the most favourable condition of irrigation is where the canal or the river has its source of supply in a great lake. For, be the rainfall ever

so heavy, the water surface in the lake will not rise very much, nor will it greatly sink at the end of a long drought. Where there is no moderating lake, a river fed from a glacier has a precious source of supply. The hotter the weather, the more rapidly will the ice melt, and this is just when irrigation is most wanted.

Elsewhere, if crops are to be raised and the rain cannot be counted on, nor well irrigation be practised, water storage becomes necessary, and it is with the help of water storage that in most countries irrigation is carried on.

Water Storage.

To one who has not given the subject attention surprise is often expressed at the large volume of water that has to be stored to water an acre of land. In the case of rice irrigation in India, it is found that the storage of a million cubic feet does not suffice for more than from 6 to 8 acres. For the irrigation of wheat about one-third this quantity is enough. It would never pay to excavate on a level plain a hollow large enough to hold a million cubic feet of water. It is invariably done by throwing a dam across the bed of a river or a valley and ponding up the water behind it. Many points have here to be considered: The length of dam necessary, its height, the material of which it is to be constructed, the area and the value of the land that must be submerged, the area of the land that may be watered. The limits of the height of a dam are from about 150 to 15 feet. If the slope of the valley is great, it may be that the volume which can be ponded up with a dam of even 150 feet is inconsiderable, and the cost may be prohibitory. On the other hand, if the country is very flat, it may be that a dam of only 20 feet high may require to be of quite an inordinate length, and compensation for the area of land to be submerged may become a very large item in the estimate. I have known of districts so flat that in order to irrigate an acre more than an acre must be drowned. This looks ridiculous, but is not really so, for the yield of an irrigated acre may be eight or ten times that of an unirrigated one; and after the storage reservoir has been emptied it is often possible to raise a good crop on the saturated bed.

The advantage of a deep reservoir is, however, very great, for the evaporation is in proportion to the area of the surface, and if two reservoirs contain the same volume of water, and the depth of one is double that of the other, the loss by evaporation from the shallow one will be double that of the deep one. In India, from time immemorial, it has been the practice to store water for irrigation, and there are many thousands of reservoirs, from the great artificial lakes holding as much as 5,000 or 6,000 millions of cubic feet, down to the humble village tank holding not a million. There are few of which the dam exceeds 80 feet in height, and such are nearly always built of masonry or concrete. For these it is absolutely necessary to have sound rock foundations. If the dam is to be of earth, the quality of the soil must be carefully seen to, and there should be a central core of puddle resting on rock and rising to the maximum height of water surface. If the dam is of masonry, there may perhaps be no harm done should the water spill over the top. If it is of earth, this must never happen, and a waste weir must be provided, if possible cut out of rock or built of the best masonry, and large enough to discharge the greatest possible flood. More accidents occur to reservoirs through the want of sufficient waste weirs or their faulty construction than from any other cause.

As important as the waste weir are the outlet sluices through which the water is conveyed for the irrigation of the fields. If possible they should be arranged to serve at the same time as scouring sluices to carry off the deposit that accumulates at the bottom of the reservoir. For, unless provided with very powerful scouring sluices, sooner or later the bed of the reservoir will become silted up, and the space available for water storage will keep diminishing. As this happens in India, it is usual to go on raising the embankment (for it does not pay to dig out the deposit), and so the life of a reservoir may be prolonged for many years. Ultimately it is abandoned, as it is cheaper to make a new reservoir altogether than to dig out the old one.

Italian Irrigation.

For the study of high-class irrigation there is probably no school so good as is to be found in the plains of Piedmont and Lombardy. Every variety of condition is to be found here. The engineering works are of a very high class, and from long generations of experience the farmer knows how best to use his water.

The great river Po has its rise in the foothills to the west of Piedmont. It is not fed from glaciers, but by rain and snow. It carries with it a considerable fertilising matter. Its temperature is higher than that of glacial water—a point to which much importance is attached for the very valuable meadow irrigation of winter. From the left bank of the Po, a few miles below Turin, the great Cavour Canal takes its rise, cutting right across the whole drainage of the country. It has a full-supply discharge of 3,800 cubic feet per second; but it is only from October to May that it carries anything like this volume. In summer the discharge does not exceed 2,200 cubic feet per second, which would greatly cripple the value of the work were it not that the glaciers of the Alps are melting then, and the great torrents of the Dora Baltea and Sesia can be counted on for a volume exceeding 6,000 cubic feet per second.

Lombardy is in no respects worse off than Piedmont for the means of irrigation; and its canals have the advantage of being drawn from the lakes Maggiore and Como, exercising a moderating influence on the Ticino and Adda rivers, which is sadly wanted on the Dora Baltea. The Naviglio Grande of Lombardy is drawn from the left bank of the Ticino, and is used largely for navigation, as well as irrigation. It discharges between 3,000 and 4,000 cubic feet per second, and nowhere is irrigation probably carried on with less expense. From between Lake Maggiore and the head of the Naviglio Grande a great new canal, the Villoresi, has been constructed during the last few years with head sluices capable of admitting 6,700 cubic feet per second, of which, however, 4,200 cubic feet have to be passed on to the Naviglio Grande. Like the Cavour Canal, the Villoresi crosses all the drainage coming down from the foothills to the north. This must have entailed the construction of very costly works.

Irrigation in Northern India.

It is in India that irrigation on the largest scale is to be found. The great plains of Northern India are peculiarly well adapted for irrigation, which is a matter of life and death to a teeming population all too well accustomed to a failure of the rain-supply.

The Ganges, the Jumna, and the great rivers of the Punjab have all been largely utilised for feeding irrigation canals. The greatest of these, derived from the river Chenab, and discharging from 10,500 to 3,000 cubic feet per second, was begun in 1889, with the view of carrying water into a tract entirely desert and unpopulated. It was opened on a small scale in 1892, was then enlarged, and ten years after it irrigated in one year 1,829,000 acres, supporting a population of 800,000 inhabitants, colonists from more congested parts of India.

The Ganges Canal, opened in 1854, at a time when there was not a mile of railway, and hardly a steam engine within a thousand miles, has a length of about 9,900 miles, including distributing channels. It was supplemented in 1878 by a lower canal, drawn from the same river 130 miles further down, and these two canals now irrigate between them 1,700,000 acres annually. On all these canals are engineering works of a very high class. The original Ganges Canal, with a width of bed of 200 feet, a depth of 10 feet, and a maximum discharge of 10,000 cubic feet per second, had to cross four great torrents before it could attain to the watershed of the country, after which it could begin to irrigate. Two of these torrents are passed over the canal by broad super-passages. Over one of them the canal is carried in a majestic aqueduct of fifteen arches, each of 50 feet span; and the fourth torrent, the most difficult of all to deal with, crosses the canal at the same level, a row of forty-seven floodgates, each 10 feet wide, allowing the torrent to pass through and out of the canal.

Elsewhere there are rivers in India, rising in districts subject to certain heavy periodical rainfall, and carrying their waters on to distant plains of very uncertain rainfall. At a small expense channels can sometimes be constructed drawing off from the flooded river water sufficient thoroughly to saturate the soil, and render it fit to be ploughed up and sown with wheat or barley, which do not require frequent watering. The canal soon dries up, and the sown crop must take its chance; but a timely shower of rain may come in to help it, or well irrigation may mature the crop. These, which are known in India as inundation canals, are of high value.

Southern India.

In Southern India there are three great rivers, drawing their supply from the line of hills called the Ghats, running parallel to and near the western coast, and after a long course discharging into the Bay of Bengal on the east coast. Against the Ghats beats the whole fury of the tropical S.W. monsoon, and these rivers for a few months are in high flood. As they approach the sea they spread out in the usual deltaic form. Dams have been built across the apex of these deltas, from which canals have been drawn, and the flood waters are easily diverted over the fields, raising a rice crop of untold value in a land where drought and famine are too common. But for the other months of the year these rivers contain very little water, and there is now a proposition for supplementing them with very large reservoirs.

A very bold and successful piece of irrigation engineering was carried out a few years ago in South India, which deserves notice. A river named the Periyar took its rise in the Ghats, and descended to the sea on the west coast, where there was no means of utilising the water, and a good deal of money had periodically to be spent in controlling its furious floods. A dam has now been built across its course, and a tunnel has been made through the mountains, enabling the reservoir to be discharged into a system of canals to the east, where there is a vast plain much in need of water.

In the native State of Mysore, in Southern India, there are on the register about 40,000 irrigation reservoirs (or tanks, as they are called), or about three to every four square miles, and the nature of the country is such that hundreds may be found in the basin of one river—small tanks in the upper branches and larger ones in the lower, as the valley widens out, and these require constant watchful attention. From time to time tropical rainstorms sweep over the country. If then even a small tank has been neglected, and rats and porcupines have been allowed to burrow in the dam, the flood may burst through it, and sweep on and over the dam of the next village, lower down. One dam may then burst after another, like a pack of cards, and terrible loss occurs.

In this State of Mysore a very remarkable irrigation reservoir is now under construction at a place called Mari Kanave. Nature seems here to have formed an ideal site for a reservoir, so that it is almost irresistible for the engineer to do his part, even although irrigation is not so badly wanted here as elsewhere. The comparatively narrow neck of a valley containing 2,075 square miles is being closed by a masonry dam 142 feet high. The reservoir thus formed will contain 30,000 million cubic feet of water, but it is not considered that it will fill more than once in thirty years. Nor is there irrigable land requiring so great a volume of water. Much less would be sufficient, so such a high dam is not needed; but the construction of a waste weir to prevent the submergence of a lower dam would require such heavy excavation through one of the limiting hills that it is cheaper to raise the dam and utilise a natural hollow in the hillside for a waste weir.

Irrigation in Egypt.

No lecture on irrigation would be complete without describing what has been done in Egypt. You are generally familiar with the shape of that famous little country. Egypt proper extends northwards from a point in the Nile about 780 miles above Cairo—a long valley, never eight miles wide, sometimes not half a mile. East and west of this lies a country broken into hills and valleys,

wild crags, level stretches, but everywhere absolutely sterile, dry sand and rock, at such a level that the Nile flood has never reached it to cover its nakedness with fertile deposit. A few miles north of Cairo the river bifurcates, and its two branches flow each for about 130 miles to the sea. As you are probably aware, with rivers in a deltaic state the tendency is for the slope of the country to be away from the river, and not towards it. In the Nile Valley the river banks are higher than the more distant lands. From an early period embankments were formed along each side of the river, high enough not to be topped by the highest flood. At right angles to these river embankments others were constructed, dividing the whole valley into a series of oblongs, surrounded on three sides by embankments, on the fourth by the desert heights. These oblong areas vary from about 50,000 to 3,000 acres. I have said the slope of the valley is away from the river. It is easy, then, when the Nile is low, to cut short deep canals in the river banks, which fill as the river rises and carry the precious mud-charged water into these great flats. There the water remains for a month or more, some three or four feet deep, depositing its mud, and then at the end of the flood it may either be run off direct into the receding river, or cuts may be made in the cross embankments and the water passed off one flat after another, and finally rejoin the river. This takes place in November, when the river is rapidly falling. Whenever the flats are firm enough to allow a man to walk over them with a pair of bullocks, the mud is roughly turned over with a wooden plough, or even the branch of a tree, and wheat or barley is immediately sown. So soaked is the soil after the flood that the seed germinates, sprouts, and ripens in April without a drop of rain or any more irrigation, except what, perhaps, the owner may give from a shallow well dug in the field. In this manner was Egypt irrigated up to about a century ago. The high river-banks which the flood could not cover were irrigated directly from the river, the water being raised as I have already described.

The Barrage.

With the last century, however, appeared a very striking figure in Egyptian history, Muhammed Ali Pasha, who came from Turkey a plain captain of infantry, and before many years had made himself master of the country, yielding only a very nominal respect to his suzerain lord, the Sultan, at Constantinople.

Muhammed Ali soon recognised that with this flood system of irrigation only one cereal crop was raised in the year, while with such a climate and such a soil, with a teeming population and with the markets of Europe so near, something far more valuable might be raised. Cotton and sugar-cane would fetch far higher prices; but they could only be grown at a season when the Nile is low, and they must be watered at all seasons. The water-surface at low Nile is about 25 feet below the flood-surface, or more than 20 feet below the level of the country. A canal, then, running 12 feet deep in the flood would have its bed 13 feet above the low-water surface. Muhammed Ali ordered the canals in Lower Egypt to be deepened; but this was an enormous labour, and as they were badly laid out and graded they became full of mud during the flood and required to be dug out afresh. Muhammed Ali was then advised to raise the water-surface by erecting a dam (or, as the French called it, a *barrage*) across the apex of the delta, twelve miles north of Cairo, and the result was a very costly and imposing work, which it took long years and untold wealth to construct, and which was no sooner finished than it was condemned as useless.

Egyptian Irrigation since the English Occupation.

With the English occupation in 1883 came some English engineers from India, who, supported by the strong arm of Lord Cromer, soon changed the situation. The first object of their attention was the *barrage* at the head of the delta, which was made thoroughly sound in six years and capable of holding up 15 feet of water. Three great canals were taken from above it, from which a network of branches are taken, irrigating the province to the left of the western, or Rosetta

branch of the river, the two provinces between the branches, and the two to the right of the eastern, or Damietta branch.

In Upper Egypt, with one very important exception (the Ibrahimieh Canal, which is a perennial one), the early flood system of irrigation, yielding one crop a year, prevailed until very recently, but it was immensely improved after the British occupation by the addition of a great number of masonry head sluices, aqueducts, escape weirs, &c., on which some 800,000*l.* was spent. With the completion of these works, and of a complete system of drainage, to be alluded to further on, it may be considered that the irrigation system of Egypt was put on a very satisfactory basis. There was not much more left to do, unless the volume of water at disposal could be increased.

Probably no large river in the world is so regular as the Nile in its periods of low supply and of flood. It rises steadily in June, July, and August. Then it begins to go down, at first rapidly, then slowly, till the following June. It is never a month before its time, never a month behind. It is subject to no exceptional floods from June to June. Where it enters Egypt the difference between maximum and minimum Nile is about 25 feet. If it rises 3½ feet higher the country is in danger of serious flooding. If its rise is 6 feet short of the average there existed in former days a great risk that the floods would never cover the great flats of Upper Egypt, and thus the ground would remain as hard as stone, and sowing in November would be impossible. Fortunately the good work of the last twenty years very much diminishes this danger.

The Assuan Dam and Reservoir.

In average years the volume of water flowing past Cairo in September is from thirty-five to forty times the volume in June. Far the greater part of this flood flows out to the sea useless. How to catch and store this supply for use the following May and June was a problem early pressed on the English engineers in Egypt.

During the time of the highest flood the Nile carries along with it an immense amount of alluvial matter, and when it was first proposed to store the flood-water the danger seemed to be that the reservoir would in a few years be filled with deposit, as those I have described in India. Fortunately it was found that after November the water was fairly clear, and that if a commencement were made even as late as that there would still be water enough capable of being stored to do enormous benefit to the irrigation.

A site for a great dam was discovered at Assuan, 600 miles south of Cairo, where a dyke of granite rock crosses the valley of the river, occasioning what is known as the First Cataract. On this ridge of granite a stupendous work has now been created. A great wall of granite 6,400 feet long has been thrown across the valley, 23 feet thick at the crest, 82 feet at the base. Its height above the rock-bed of the river is 130 feet. This great wall or dam holds up a depth of 66 feet of water, which forms a lake of more than 100 miles in length up the Nile Valley, containing 38,000 million cubic feet of water.

The dam is pierced with 180 sluices, or openings, through which the whole Nile flood, about 360,000 cubic feet per second, is discharged. A flight of four locks, each 260 × 30 feet, allows of free navigation past the dam. The foundation-stone of this great work was laid in February 1899, and it was completed in less than four years. At the same time a very important dam of the pattern of the barrage north of Cairo was built across the Nile at Assiut, just below the head of the Ibrahimieh Canal, not with the object of storing water, but to enable a requisite supply at all times to be sent down that canal.

The chief use of the great Assuan reservoir is to enable perennial irrigation, such as exists in Lower Egypt, to be substituted in Upper Egypt for the basin system of watering the land only through the Nile flood; that is, to enable two crops to be grown instead of one every year, and to enable cotton and sugar-cane to take the place of wheat and barley. But a great deal more had to be done in order to obtain the full beneficial result of the work. About 450,000 acres of basin irriga-

tion are now being adapted for perennial irrigation. Many new canals have had to be dug, others to be deepened. Many new masonry works have had to be built. It is probable the works will be finished in 1908. There will then have been spent on the great dam at Assuan, the minor one at Assiut, and the new canals of distribution in Upper Egypt about six and a half millions sterling. For this sum the increase of land rental will be about 2,637,000*l.*, and its sale value will be increased by about 26,570,000*l.*

Drainage.

In the great irrigation systems which I have been describing for a long time little or no attention was paid to drainage. It was taken for granted that the water would be absorbed, or evaporated, and get away somehow without doing any harm. This may hold good for high-lying lands, but alongside of these are low-lying lands, into which the irrigation water from above will percolate and produce waterlogging and marsh. Along with the irrigation channel should be constructed the drainage channel, and Sir W. Willcocks, than whom there is no better authority on this subject, recommends that the capacity of the drain should be one-third that of the canal. The two should be kept carefully apart—the canal following the ridges, the drain following the hollows of the country, and one in no case obstructing the other. This subject of drainage early occupied the attention of the English engineers in Egypt. In the last twenty years many hundred miles of drains have been excavated, some as large as 50 feet width of bed and 10 feet deep.

Irrigation in America.

If it is to Italy that we should look for highly finished irrigation works and careful water distribution, and to India and Egypt for widespreading tracts of watered land, it is to America that we naturally look for rapid progress and bold engineering. In the Western States of America there is a rainfall of less than 20 inches per annum, the consequence of which is a very rapid development of irrigation works. In 1889 the irrigation of these Western States amounted to 3,564,416 acres. In 1900 it amounted to 7,539,545 acres. Now it is at least 10,000,000 acres. The land in these States sells from 10*s.* to 1*l.* per acre if unirrigated. With irrigation the same land fetches 8*l.* 10*s.* per acre. The works are often rude and of a temporary nature, the extensive use of timber striking a foreigner from the Old World. Some of the American canals are on a large scale. The Idaho Company's canal discharges 2,585 cubic feet, the Turlook Canal in California 1,500 cubic feet, and the North Colorado Canal 2,400 cubic feet per second. These canals have all been constructed by corporations or societies, in no case by Government. On an average it has cost about 32*s.* per acre to bring the water on to the land, and a water-rate is charged of from 2*l.* 8*s.* to 4*l.* per acre, the farmer paying in addition a rate of from 2*s.* to 10*s.* per acre annually for maintenance. Distributary channels of less than 5 feet wide cost less than 100*l.*, up to 10 feet wide about 150*l.* per mile.

The Introduction of Irrigation into a Country.

It is evident that there are many serious considerations to be taken into account before entering on any large project for irrigation. Statistics must be carefully collected of rainfall, of the sources of water supply available, and of the amount of that rainfall which it is possible to store and utilise. The water should be analysed if there is any danger of its being brackish. Its temperature should be ascertained. It should be considered what will be the effect of pouring water on the soil, for it is not always an unmixed benefit. A dry climate may be changed into a moist, and fever and ague may follow. In India there are large tracts of heavy black soil, which with the ordinary rainfall produce excellent crops nine years out of ten, and where irrigation would rather do harm than good. But in the tenth year the rains fail, and without artificial irrigation the soil will yield nothing. So terrible may be the misery caused by that tenth year of

drought that even then it might pay a Government to enter on a scheme of irrigation. But it is evident that it might not pay a joint-stock company.

In all cases it is of the first importance to establish by law the principle that all rivers or streams above a certain size are national property, to be utilised for the good of the nation. Even where there is no immediate intention of constructing irrigation works it is well to establish this principle. Otherwise vested rights may be allowed to spring up, which it may be necessary in after years to buy out at a heavy cost.

Modes of Distributing and Assessing Water.

Where the river is too inconsiderable to be proclaimed as national property, and where there is no question of spreading the water broadcast over the land, but of bestowing it with minute accuracy over small areas to rear valuable plants, such as fruit-trees, it may be very well left to local societies or to syndicates of farmers to manage their own affairs. Where irrigation is on a larger scale, and its administration is a matter of national importance, the control of the water requires the closest consideration, especially if, as is usually the case, the area which may be irrigated exceeds the volume of water available to irrigate it, and where the water is delivered to the fields by gravitation without the labour of raising it. It must be decided on what principle the farmer's right to the water is to be determined. Is he to obtain water in proportion to the area of his land which is irrigable? If part of the irrigable land is not yet cultivated, is some of the supply to be reserved for such land? Is he to pay in proportion to the area actually watered each crop, or to the area which he might water if he chose? Where the slope of the land is sufficient to allow the water to flow freely out of sluice into the field channel, it is not difficult to measure the water discharged. Modules have been invented for this purpose, and the owner of the field may be required to pay for so many cubic feet of water delivered. The Government or the association owning the canal will then have nothing to do with the way in which the water is employed, and self-interest will force the farmer to exercise economy in flooding his land. But even then precautions must be taken to prevent him from keeping his sluice open when it should be shut.

In Italy and in America water is generally charged by the module; but in many cases, where the country is very flat, the water cannot fall with a free drop out of the sluice, and, as far as I know, no satisfactory module has yet been invented for delivering a constant discharge through a sluice when the head of water in the channel of supply is subject to variation. These are the conditions prevailing in the plains of Northern India, where there is a yearly area of canal irrigation of about six millions of acres. The cultivator pays not in proportion to the volume of water he uses, but on the area he waters every crop, the rate being higher or lower according as the nature of the crop demands more or less water.

The procedure of charging for water is, then, as follows: When the crop is nearly ripe the canal watchman, with the village accountant and the farmers interested, go over the fields with a Government official. The watchman points out a field which he says has been watered. The accountant, who has a map and field-book of the village, states the number and the area of the field and its cultivator. These are recorded along with the nature of the crop watered. If the cultivator denies that he has received water, evidence is heard and the case is settled. A bill is then made out for each cultivator, and the amount is recovered with the taxes.

This system is perfectly understood, and works fairly well in practice. But it is not a satisfactory one. It holds out no inducement to the cultivator to economise water, and it leaves the door open to a great deal of corruption among the canal watchmen and the subordinate revenue officials.

Government Control of Water Supply.

Where the subject agricultural population is unfitted for representative government it is best that the Government should construct and manage the

irrigation, on rules carefully considered and rigorously enforced, through the agency of officers absolutely above suspicion of corruption or unfair dealing. Such is the condition in Egypt and in the British possessions in India. Objections to it are evident enough. Officials are apt to be formal and inelastic, and they are often far removed from any close touch with the cultivating classes. But they are impartial and just, and I know of no other system that has not still greater defects.

Even if the agricultural classes in India were much better educated than they are, it would still be best that the control of the irrigation should rest with the Government. By common consent it is the Government alone that rules the army. Now the irrigation works form a great army, of which the first duty is to fight the grim demon of famine. Their control ought, therefore, to rest with the Government; but the conditions are very different when the agricultural classes are well educated and well fitted to manage their own affairs.

Irrigation is too new and experimental in America for us to look there for a well-devised scheme of water control. The laws and rules on the subject vary in different States, and are often contradictory. It is better to look at the system evolved after long years in North Italy.

The Italian System.

I have already alluded to the great Cavour Canal in Piedmont. This fine work was constructed by a syndicate of English and French capitalists, to whom the Government gave a concession in 1862. Circumstances to which I need not allude ruined this company, and the Government, who already had acquired possession of many other irrigation works in Piedmont, took over the whole Cavour Canal in 1874, a property valued at above four millions sterling, and ever since the Government has administered it.

The chief interest of this administration centres in the Irrigation Association West of the Sesia,[1] an association that owes its existence to the great Count Cavour. It takes over from the Government the control of all the irrigation effected by the Cavour and other minor canals within a great triangle lying between the left bank of the Po and the right bank of the Sesia. The association purchases from the Government from 1,250 to 1,300 cubic feet per second. In addition to this it has the control of all the water belonging to private canals and private rights, which it purchases at a fixed rate. Altogether it distributes about 2,275 cubic feet per second, and irrigates therewith about 141,000 acres, of which rice is the most important crop. The association has 14,000 members, and controls 9,600 miles of distributary channels. In each parish is a council, or, as it is called, a *consorzio*, composed of all landowners who take water. Each *consorzio* elects one or two deputies, who form a sort of water Parliament. The deputies are elected for three years, and receive no salary. The assembly of deputies elects three committees—the direction-general, the committee of surveillance, and the council of arbitration. The first of these committees has to direct the whole distribution of the waters, to see to the conduct of the *employés*, &c. The committee of surveillance has to see that the direction-general does its duty. The council of arbitration, which consists of three members, has most important duties. To it may be referred every question connected with water-rates, all disputes between members of the association or between the association and its servants, all cases of breaches of rule or of discipline. It may punish by fines any member of the association found at fault, and the sentences it imposes are recognised as obligatory, and the offender's property may be sold up to carry them into effect. An appeal may be made within fifteen days from the decisions of this council of arbitration to the ordinary law courts, but so popular is the council that, as a matter of fact, such appeals are never made.

To effect the distribution of the water the area irrigated is divided into districts, in each of which there is an overseer in charge and a staff of guards to see to the opening and closing of the modules which deliver the water into the minor

[1] See Mr. Elwood Mead's *Report on Irrigation in Northern Italy*, printed for the Department of Agriculture, Washington, 1904.

watercourses. In the November of each year each parish sends in to the direction-general an indent of the number of acres of each description of crop proposed to be watered in the following year. If the water is available the direction-general allots to each parish the number of modules necessary for this irrigation; but it may quite well happen that the parish may demand more than can be supplied, and may have to substitute a crop like wheat, requiring little water, for rice, which requires a great deal.

The Government executes and pays for all repairs on the main canals. It further executes, at the cost of the Irrigation Association, all repairs on the minor canals. The association, then, has no engineers in its employ, but a large staff of irrigators. The irrigation module employed in Piedmont is supposed to deliver 2·047 cubic feet per second. The Association West of the Sesia buys from the Government what water it requires at a rate fixed at 800 liras per module, or 15*l.* 12*s.* 7*d.* per cubic foot per second per annum.

The association distributes the water by module to each district, and the district by module to each parish. Inside the parish each farmer pays, according to the area he waters, a sum to cover all the cost of the maintenance of the irrigation system, and his share of the sum which the association has to pay to the Government. This sum varies from year to year according as the working expenses of the year increase or diminish.

I have already mentioned the recently constructed Villoresi Canal in Lombardy. This canal belongs to a company, to whom the Government has given large concessions. This company sells its water wholesale to four districts, each having its own secondary canal, the cubic mètre per second, or 35·31 cubic feet per second, being the unit employed. These districts, again, retail the water to groups of farmers termed *comizios*, whose lands are watered by the same distributary channels, their unit being the litre, or ·035 cubic foot per second. Within the *comizio* the farmer pays according to the number of hours per week that he has had the full discharge of the module.

I have thought it worth while to describe at some length the systems employed on these Italian canals, for the Italian farmers set a very high example, in the loyal way in which they submit to regulations which there must at times be a great temptation to break. A sluice surreptitiously opened during a dark night, and allowed to run for six hours, may quite possibly double the value of the crop which it waters. It is not an easy matter to distribute water fairly and justly between a number of farms at different levels, dependent on different watercourses, cultivating different crops. But in Piedmont this is done with such success that an appeal from the council of arbitration to the ordinary law courts is unheard of. It is thought apparently as discreditable to appropriate an unfair supply of water as to steal a neighbour's horse, as discreditable to tamper with the lock of the water module as with the lock of a neighbour's barn.

Mr. Schuyler's Views as to Government Control.

Where such a high spirit of honour prevails I do not see why syndicates of farmers should not construct and maintain a good system of irrigation. Nevertheless, I believe it is better that Government should take the initiative in laying out and constructing the canals and secondary channels at least. A recent American author, Mr. James Dix Schuyler, has put on record: 'That storage reservoirs are a necessary and indispensable adjunct to irrigation development, as well as to the utilisation of power, requires no argument to prove. That they will become more and more necessary to our Western civilisation is equally sure and certain; but the signs of the times seem to point to the inevitable necessity of Governmental control in their construction, ownership, and administration.'

This opinion should not be disregarded. Sir W. Willcocks has truly remarked: 'If private enterprise cannot succeed in irrigation works of magnitude in America, it will surely not succeed in any other country in this world.' What its chances may be in South Africa I leave to my hearers to say. It is not a subject on which a stranger can form an opinion.

CAPE TOWN.

WEDNESDAY, AUGUST 16.

The following Papers were read:—

1. *Cape Town Colonial Dutch Architecture.* *By* C. H. SMITH.

Architecture at the Cape of Good Hope from 1652 to 1850—The earliest Cape Post Office, Post Office stones, &c.—First building at the Cape, Van Riebeek's Fort—Present Castle: its constructions and details—Plan and views—Castle gateway—Interior of Castle—Entrance to Council Chamber—Old building on Castle outworks, now demolished.

The works of Simon Van Der Stel at Constantia—Plan of house and description—Wine-house Constantia and sculptured pediment—The work of the sculptor Anzigt at the Cape: Pulpits, Dutch Reformed and Lutheran Churches.

Developments under Willum Adrian Van Der Stel—Old church, Cape Town—Plan of typical peninsular town house, Cape farm-houses—The progress of Stellenbosch—The conspiracy against the Van Der Stels and their fall—Illustration of the Governor Willum Van Der Stel's house and estate as shown in the accusation—Illustration of the Governor Willum Van Der Stel's house and estate as shown in his defence.

2. *Steam Turbines as applied to Ocean Liners.* *By* Professor J. HARVARD BILES, *LL.D.*

THURSDAY, AUGUST 17.

The following Papers were read:—

1. *Roller-bearings.* *By* THOMAS W. HOW, *F.R.G.S.*

The present divergence of opinion as to the practical application of roller-bearings to movable and fixed machinery is attributed to their limited application and consequent trials, to the expense of re-fitting existing plant, and to the difficulty of obtaining comprehensive data of economies effected.

The requirements of a satisfactory roller-bearing are that the various parts must be proportioned with reference to their relative movements, and constructed of materials suitable to withstand the stresses imposed upon them. For heavy loads the author recommends high-class finish and hardened steel, but for light loads milder steel of good quality, with due regard to load in each case.

The efficiency of roller-bearings largely depends upon true parallelism, proper spacing of rollers, and proportionate diameter, length, and hardness of the rollers, in order to withstand fatigue.

Of the various contrivances for spacing the rollers the author regards the 'Empire' floating cage as the most satisfactory, owing to its simplicity of construction and easy adjustment.

Solid rollers are advocated rather than spiral, hollow, or rollers threaded on spindles. Provision for end-thrust or lateral movement of a roller-bearing is necessary, and several methods are described.

The author, whilst contending that roller-bearings should be produced at reasonable cost, regards first cost as secondary to ultimate economy in motive power, measured by savings in coal or electrical current per annum, and lubrication.

Recent tests on line shafting electrically driven fitted with roller-bearings effected a saving of 24·4 per cent. of the power required to run the motor and counter-shaft with machines in full work.

Earlier unsuccessful experiments made with roller-bearings are attributed to causes now well understood and avoided, such as excessive rigidity and

improper load adjustment, which are now obviated by means of swivel seatings so that the load is evenly distributed.

Examples are given of roller-bearings successfully applied to the axles of coal-weighing shoots, each bearing supporting a load of five tons on eight rollers on mild-steel axles, where the total tractive resistance was reduced to 3 lbs. per ton of load.

In tramway and railway vehicles a series of tests has also proved the starting effort to be 3 lbs. per ton of load, giving a coefficient of friction of 0·0013, including wheel friction upon straight level rails. This reduction effected a saving in electrical energy equal to 50 per cent. of journal friction, equivalent to ½*d.* per car mile, or 50*l.* per car per annum.

On the Birmingham electric tramways a saving of 24·30 per cent. of tractive force per ton of load was obtained, and a saving of 1·035 unit per trip, equivalent to 38*l.* 16*s.* 3*d.* per car per annum.

At Southport the average energy consumption of roller-bearing cars was 0·55 unit per car mile with a mean speed of 10·3 miles per hour, as against one unit per car mile with ordinary bearings and a mean speed of 8·6 miles per hour. The *mean* current consumption with ordinary bearings was 0·797 unit per car mile, and with roller-bearings 0·389, showing a saving of 0·408 unit per car mile, or a saving of 68*l.* per car per annum.

As examples of railway tests, the earlier trials on the London, Brighton, and South Coast Railway are cited, where, after six years' service and 120,000 miles run, a saving of 12½ per cent. was shown in coal consumption.

On the Indian State Railways a saving of 12·36 per cent. according to coal consumption, and 11·76 per cent. according to water consumption, was effected, or a mean of 12 per cent., equal to a saving of 135 tons of coal per train per annum, or 67*l.* 10*s.* per train of six coaches. Taking the life of the roller-bearing at ten years, and allowing for sinking fund and interest on the capital cost of the bearings for that period, the annual charge per train is only 0·56 per cent. of the actual economy effected, plus the increase of traffic obtained by longer trains without any appreciable increase in the expenditure of energy.

On the Liverpool Overhead Railway roller-bearing tests proved that the reduction per ton mile of coal consumption was equal to 9 per cent., and that longer trains could be employed.

On the Northern of France Railway the tests proved a saving in tractive resistance of 6 to 1 in favour of roller-bearings, at speeds varying from 50 to 75 miles per hour.

The reduction of tractive resistance and the correspondingly diminished wear and tear of materials generally, combined with increased comfort in smooth, easy running, the smarter handling of trains, the acceleration of speed, and the increase of carrying loads by means of successful roller-bearings, are subjects well worth the careful consideration of engineers.

2. *The Motor-Car in South Africa.* *By* ALFRED T. HENNESSY.

Introduction.—Aim of paper to briefly give results of practical experience in motor construction best suited for South Africa—As no data exist, difficulty of comparison of various forms of motor construction.

Electric, Steam, and Internal Combustion Motor-Cars.

Unsuitability of electric vehicles for South Africa—Great improvement in more recent construction of steam-cars—Advantages and disadvantages of the modern steam-car—The internal combustion motor-car best suited for South Africa—Consideration of detailed construction of internal combustion motor-cars.

The Engine.—Slow and high speed—Advantage of multiple cylinders—Necessity of more efficient cooling—The best method of connecting up the water circulation.

Ignition.—Various forms considered—High-tension magneto with alternate ordinary accumulator and coil system best suited for South Africa.

Carburettor.—Frequent unsatisfactory working and difficulty of constructing a thoroughly satisfactory automatic one—Need of positive adjustment from dashboard.

Lubrication.—Automatic pressure the most suitable form.

Governor.—The general form of—Little need of, if positively worked throttle fitted.

Clutch.—The various forms—The necessity of one constructed to allow slipping without injury to working parts—The internal expanding metal to metal very suitable—The Hele-Shaw clutch most suitable for South Africa.

Speed Gear.—Various forms of—Reliability of wheel gear, making it the most suitable for South Africa.

Transmission Gear.—Different forms of—Desirability of enclosing chains—Cardan shaft with bevel gear and live axle the ideal form for this country.

Frame.—Extraordinary reliability of standard makes—Different methods of attachment engine and gear—Advantages of three-point suspension.

Springs.—Need of fitting more efficient—Advantages of lengthened wheel base—Three point suspension applied to the springing of a car.

Brakes.—Different forms—Best form metal to metal expanding ring.

Steering.—Wheel or tiller, the former best suited to South Africa.

Wheels.—Advantages of equal size—Best form Artillery type.

Parts, motor-cars, most liable to failure—Instances of such failures.

Finally, what may be considered an ideal car for South Africa.

FRIDAY, AUGUST 18.

The following Paper was read:—

Cape Government Railways. By A. M. TIPPETT, *Assoc.M.Inst.C.E*

JOHANNESBURG.

TUESDAY, AUGUST 29.

The President delivered his Address (see p. 490), after which the following Papers were read:—

1. *Wireless Telegraphy. By* Sir W. H. PREECE, *K.C.B., F.R.S.*[1]

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2. *The Strength of Winding Ropes in Mines.*
By Professor JOHN PERRY, *F.R.S.*

WEDNESDAY, AUGUST 30.

The following Papers were read:—

1. *Electric-power Distribution in the Rand.*
By ROBERT HAMMOND, *M.Inst.C.E.*

The object of this paper was to raise two questions: first, whether the working of the mines could not be cheapened by the greatly extended application of electric power; and secondly, whether such electric power could be more economically

[1] Published in the *Electrician.*

produced by each mine or group of mines laying down its own plant, or by means of centralisation of generation in works serving a number of mines.

In the United Kingdom a great extension in the application of electricity has taken place since the report on the use of electricity in mines was issued by the Home Office in 1904.

As regards the Rand, the author believes that almost every operation at present performed by steam could be more economically effected by electricity if the power were generated at a central power station supplying the whole of the mines.

He pointed out as an instance of the economy effected by the use of electricity that in the case of drills worked by compressed air supplied from the surface an inevitable loss of from 50 to 75 per cent. of the power takes place owing to leakage and friction. Portable electrically driven compressors placed in ventilated positions close to the workings would result in a loss of only about 22 per cent.

Turning to the question of whether the supply of electrical energy could be more cheaply obtained from one central station or from separate works supplying each group of mines, it must be considered whether the advantages of centralisation do not outweigh the disadvantages arising from losses in transmission through long lengths of distributing mains.

To take an extreme case, there would be no difficulty in supplying electrical energy to the mines of the Rand from a central power house at the Victoria Falls on the Zambesi; but, even disregarding the cost of the enormous works necessary for utilising the water-power, the annual capital charges on the cost of the transmission lines would far outweigh the annual outlay on coal used in works laid down close to the Rand.

The costs of generation and distribution of electrical energy divide themselves as follows:—(1) Capital charges; (2) Working expenses.

As regards capital charges the advantages gained by centralisation and the resultant diversity factor are that the plant required is reduced in total capacity; also that plants of larger size can be used and the capital expenditure thereon minimised.

As regards the effect of centralisation on working expenses, and considering steam-driven plant, the consumption of coal is reduced owing to the size of the generating plant. A saving is also made in water consumption, and in oil, waste, and stores, for the same reason. A great saving would be effected in wages, as the same number of men would be required to operate, say, six plants of 1,000 kwts. as would be required to work the same number of plants ten times the size. Similar savings would be effected in the other items of working costs.

As regards the size of a central station to supply the whole of the Rand the total consumption of power at present may be estimated from the amount of coal consumed annually. In the report of Mr. T. R. Price, the general manager of the Central South African Railways, for 1904 it is stated that the coal carried amounted to 1,864,926 tons. Assuming that 1,250,000 tons out of this total are taken by the mines on the Rand, and assuming that the coal had a calorific value of from 8,000 to 12,000 B.T.U.s per lb., and, further, that 6 lbs. of coal were used for every brake horse-power hour, the total power consumed on the Rand would be 416,666,666 horse-power hours, or, say, 400,000,000 horse-power hours per annum—equivalent to an average output throughout the area of over 45,000 horse-power, working day and night without intermission.

The above consumption of power is equivalent to 300,000,000 units (k.w. hours) of electrical energy per annum.

In order to arrive at the total capacity of a central power house to deal with this output it is necessary to consider the load and diversity factors which would be obtained.

As already indicated the extent to which the aggregation of output leads to economy in working cost practically turns upon the excellence of the load and diversity factors which would result from the supply to a large number of consumers. The term 'load factor' is the name given to the ratio of the actual output of any works during a given period to what that output would have been had the works been operating at their maximum rate throughout that period.

As regards the 'diversity factor' the term is used to denote the ratio of the maximum load to be supplied by the central power plant to the sum of the individual consumer's maxima. Its value depends, of course, upon the extent to which the various consumers' demands overlap one another.

On the Rand the load factor of the plant at many of the individual mines is as high as 0·5 or 0·6. It may therefore be assumed, in order to be on the safe side, that the average of the consumers' load factors would be about 40 per cent.

On the basis of a consumption of 300,000,000 units per annum and a 40 per cent. load factor, the sum of the consumers' maximum demands would be 82,200 kwts.

On the assumption of a diversity factor of 60 per cent. and a 20 per cent. loss in distribution and transformation, a plant capacity at the generating works of 60,000 kwts. would be required.

Capital Outlay.

At the generating works provision should be made for seven generating sets, each of a capacity of 10,000 kilowatts. The cost of the power house and generating plant, electric lines, transformers, sub-stations, storage tank, land and road-making, contingencies, engineering and supervision fees, &c., is estimated at 1,850,000*l.*, and the working capital at 150,000*l.*, making a total of 2,000,000*l.*

Costs of Working.

These are compiled on the basis of an output of 375,000,000 units, and may be estimated as follows:—

		£
Coal on the basis of 4 lbs. per unit and 10*s.* 6*d.* per ton (of 2,000 lbs.)		393,750
Water (to make up for condensing and for boiler feed), $1\frac{1}{4}$ gallon per unit at 3*s.* 6*d.* per 1,000 gallons		82,031
Oil, waste, and stores		3,125
Wages		52,000
Management, rent, rates, insurance, &c.		12,000
Repairs and maintenance, $\frac{1}{2}$ per cent. on capital outlay, viz.	£2,000,000	
Less working capital	150,000	
	£1,850,000	9,250
		552,156
Add 5 per cent. for contingencies		27,607
		579,763
Capital charges—		
5 per cent. on 660,000 debentures and 10 per cent. on 1,340,000 ordinary capital		167,000
Reserve fund—		
For depreciation and antiquation fund and 2 per cent. on capital outlay on plant		37,000
Total		783,763
Margin to the good		91,237
		£875,000

Revenue.

300,000,000 units delivered to consumers at 0·7*d.* per unit	£875,000

Financial Results.

On the above basis it will be seen that a sufficient profit would be available to provide 5 per cent. on the debenture capital and 10 per cent. on the ordinary capital after setting aside 37,000*l.* per annum to reserve fund to cover depreciation and antiquation of the plant.

The ideal position for the works would be about eight miles to the east of Johannesburg. Is water available in that vicinity in sufficient quantity to provide that required at the price taken in the estimated working expenses? If not, where can it be obtained, and at what cost?

Presuming for the purpose of illustration that ample water were available at Vereeniging at a distance of, say, thirty-five miles from Johannesburg, an additional expenditure of capital of, say, 80,000*l.* for the construction of a weir dam would be necessary. The energy could be transmitted from Vereeniging to Johannesburg at 70,000 volts by three sets of transmission lines consisting of three cables each. The energy would be received at three sub-stations situated on the west, east, and centre of the Rand, and distributed thence as in the case of a central station situated on the Rand.

The total cost of this transmission line and of the additional transformers, &c., would amount to 200,000*l.* On the other hand the outlay of the 300,000*l.* included above to cover the cost of water storage works would be avoided. The increased cost owing to the transmission of the energy would be more than compensated for by the lower price of the coal and water at Vereeniging, always assuming that arrangements could be made for the use of the Vaal River.

If such arrangements could be made the future central power distribution station for the Rand will probably be situated there and the supply given at 0·6*d.* per unit.

In conclusion the writer expressed his great thanks to the engineers and managers of the Rand mines who so heartily and fully responded to his requests for data as to the present methods.

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2. *Water-power Plants.* *By* Elsdon Dew.

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3. *Dust Fuel.* *By* A. M. Robeson.

It is well known that practically perfect combustion can be obtained with powdered fuel, and that only the theoretical quantity of oxygen is necessary; in fact, the mixture of air and fuel in this form can, for all practical purposes, be considered as a 'gas,' containing within itself all things necessary for complete combustion.

A gas which contains within itself all things necessary for complete combustion is also an explosive mixture, having a definite rate of transmission of the point of explosion or ignition for any given conditions of temperature and pressure, and this is true of coal dust and air; but fortunately in this case the rate of transmission is comparatively slow, and when the volume of mixture in use is small, and kept moving, no explosions are possible. It is this difficulty of exploding or igniting such a mixture which renders it necessary to surround the issuing jet of fuel and air with incandescent bricks, and at the same time is that which marks the beginning of the troubles of the experimenter; for, as would be expected, the perfect combustion of a given quantity of fuel with its exact chemical equivalent of air in a very short time will result in a maximum temperature which, together with the powerful slagging action of the dust-ash, soon destroys ordinary bricks in the hottest zone and fills the furnace with slag in the cooler portions.

Theoretically the cross-section of the furnace should be altered for every change in the rate of firing; but as this is for practical reasons impossible the idea cannot be entertained. . . . It will be seen, then, from theoretical consideration—as is actually borne out in practice—that when powdered fuel is being burned in the ordinary manner, *i.e.*, in a straight-through furnace, the conditions of quality and quantity of fuel and the amount of air and draught must be maintained constant within narrow limits, especially if the coal be of medium or poor quality.

It was the appreciation of the necessity of a furnace which would automatically

maintain a stable condition of combustion under all variations of fuel supply, &c. together with the belief that, could such a thing be found, the beautiful perfection of this method of burning coal would eventually overcome all the remaining difficulties in the way of its practical application, which led the writer on through the experiments that he then described.

It was at this time that a correct idea was obtained of the principles governing the combustion of explosive mixtures in motion, and it became clear that means must be provided for heating the incoming mixture in some other manner than by radiation from the brickwork alone. It was recognised that what was required was a source of heat which would have a natural and strong tendency to travel parallel and in a contrary direction to the incoming combustible.

When considering the economical aspect of the question it is to be remembered that money must be expended to make coal-dust, and that this amount is to be added to the original cost of the coal for dust-firing when comparisons are made.

It will be of interest to see what percentage improvement is necessary over present boiler practice on the Rand to make dust-firing a commercial success. For this purpose it will be assumed that the boiler plant will be large enough to consume ninety tons of coal per day of twenty-four hours, and that ample spare machinery be provided. The cost per annum would then be :—

	£
Interest and redemption	402
Repairs and maintenance	550
Sundry stores	300
Power	2,970
	4,222
Deduct labour saved	1,034
	£3,188

This amount divided by the yearly tonnage, viz., 32,850 tons, makes the cost per ton 1*s.* 11½*d.* As the average cost of coal to the majority of mines on the Rand is about 12*s.*, it will be seen that an average saving of 16 per cent. must be shown.

On referring to the tabulated statement of the tests it will be seen that with dust-firing 7·8 lbs. of water were evaporated from and at 212° F. per lb. of coal, and with hand-firing 5·5 lbs. were evaporated; or, in other words, 29 per cent. of the coal was saved. This figure when compared with the limiting one of 16 per cent. shows that, even with the means now at our disposal, when compared with poor hand-firing, dust-firing is commercially possible.

FRIDAY, SEPTEMBER 1.

The following Papers were read :—

1. *The Harbours of South Africa, with special reference to the Causes and Treatment of Sandbars.*

By CATHCART W. METHVEN, *F.R.S.E., M.Inst.C.E.*

The author gave a short description of the littoral of South Africa from Cape Town to Delagoa Bay, referring to the remarkable absence of deep-water indentations forming natural harbours between these points, and gave some of the reasons therefor. The description included some of the most notable features of the southern and eastern coast lines of Cape Colony and Natal, including Zululand. Reference was also made to the formation of some of the lakes and lagoons and the gradual elevation of the coast belt as affecting these.

Brief descriptions of Table Bay harbour and the proposed works of dock extension by the author and Mr. Hammersley-Heenan, general manager and engineer to the Cape Harbour Board, at the estimated cost of 3,561,757*l.*, were then given, together with statistics showing the probable increase in customs, revenue, imports, and exports.

The embayments on the south-east littoral as far as Algoa Bay were then described, with brief references as to their suitability for the construction of harbours, including St. Sebastian Bay, Plettenberg Bay, and Mossel Bay.

Algoa Bay.—The author referred to the main features of this harbour and the remarkable strides which have been made in its commercial prosperity in spite of the landing difficulties due to its exposed position and the want of adequate sheltering works. A short description of the existing jetties was given and reference made to two important schemes now under consideration—one, by Messrs. Coode, Son & Matthews, to project two great breakwaters into the bay in front of the town of Port Elizabeth, so as to form an inclosed harbour of some 800 acres; and the other, by the author, to open up the Zwartkops River, which runs into Algoa Bay, about five and a half miles to the northward. A description was given of the present conditions of the Zwartkops River and of the proposed works. The question of sand travel along the shore of Algoa Bay as affecting these was also referred to.

Formation and Treatment of Bars.—Under this heading the author discussed the various causes to which may be attributed the formation of bars at the mouths of the rivers and lagoons on the south-east African coast and the variations of their form which take place in accordance with the physical features of the rivers and lagoons concerned, and of the coast line in proximity to their outlets. This was illustrated by reference to the bars at the Kowie River, Buffalo River, and St. John's River.

Lagoons.—The discussion of the formation and treatment of bars was continued under this heading, together with a full description of the physical features of these lagoons and the causes of their formation, as well as of the sand-spits separating them from the ocean. Special reference was made, in illustration of the subject, to the lagoons at Durban, Umhlatuzi, and St. Lucia, in Natal and Zululand.

Port Alfred.—A description of this river was given, and a short historical sketch of the engineering works which were carried out, together with their results, and the works proposed by the author to reopen the river by the construction of a new outlet, towards which end the existing works are to be utilised.

East London.—A short description was given of the original condition of the Buffalo River and of the works which have been carried out to open it for navigation, special reference being made to the successful application of sand-pump dredging to the bar in the open sea. Statistics showing the increase of trade were given.

Port St. John.—A general description was given of the river and the physical conditions affecting its outlet, especially as regards the formation of the bar and the effect of the river freshets on same. A short description of the works proposed by the author for its improvement was also given.

Port Shepstone.—Only a short reference was made to this river and to the necessity for a most careful investigation into the physical characteristics, and the fullest recognition of the ultimate expense before works are undertaken to open up these small rivers.

Durban.—A full description was given of this port and its lagoon, and of some of the natural causes which have operated in its formation. Statistics were given showing the increase in its commercial prosperity between 1846 and 1904. The original condition of the bar at the mouth of the lagoon and the changes which occurred in its form at different periods in the progress of the works were described in detail. Special reference was made to the important operations of dredging on the bar in the open sea and the results which have been attained.

Delagoa Bay.—A short description was given of this harbour, which is a Portuguese possession, special reference being made to certain features which resemble

those previously referred to under the heading of 'lagoons,' and to the shoals which constitute bars to navigation, both at Lorenço Marques and at the mouth of the bay.

2. *The Architectural Problem in South Africa.* *By* WILLIAM LUCAS, *F.R.G.S.*

Perhaps more closely than any other function of humanity is architecture bound up with the life of the race; and amid strenuously utilitarian demands and limitations its story is being written on South African soil. A few reminiscences of early settlement, the result of contact with the Dutch life of the seventeenth century, remain. Otherwise all is essentially modern, and a great deal of the earlier work is the joint product of professionals and laymen.

With the exception of Johannesburg and Cape Town—which in a degree remind one of America—the phase of building is of British type, though expressing greater independence of thought. The absence of such educational institutions as Great Britain and America possess has some compensation in principals, staff, and pupils being brought into closer touch with building operations, and in practice being concentrated on more limited areas.

The temper of semi-tropical environments reduces the need for the provisions that characterise the interiors of northern climes, though the fact of coloured domestic labour presents certain problems that have to be met, and especially in those latitudes with trying climates. The supreme demands are in the direction of tree planting; a keen regard for the face of nature; sheltered coverings for the enjoyment of tempered sunshine, bracing breezes, and brilliant skies.

With the ample resources at the disposal of South Africa in imported and local materials, and the scientific knowledge available, it is felt that there ought to be more extensive use of those that time and climate can enrich. While thankful for Bath and New Zealand stones, local stone should be far more in evidence, and design be of more tempered severity. The accepted and extensive use of cement stucco makes restraint—the most valuable quality in architectural composition—very difficult to observe. There are, however, indications of stern struggle against surface effect, and some few masterly compositions may be seen even in stucco.

Unfortunately nepotism and social qualities—far more than is possible in older and more extensive communities—rather than merit have much to do with the character of South African architecture. The public buildings, however, are generally the results of open competition, and more fully express the possibilities of quality and the extent of 'the force behind the hill' panting for its opportunity.

3. *Irrigation in South Africa.* *By* C. D. H. BRAINE.

4. *The Copper Deposit of Little Namaqualand.* *By* J. H. RONALDSON.

Section H.—ANTHROPOLOGY.

President of the Section—A. C. Haddon, M.A., Sc.D., F.R.S.

CAPE TOWN.

WEDNESDAY, AUGUST 16.

The President delivered the following Address:—

There are various ways in which man can study himself, and it is clearly impossible for me to attempt to give an exposition of all the aims and methods of the anthropological sciences; I propose, therefore, to limit myself to a general view of South African ethnology, incidentally referring to a few of the problems that strike a European observer as needing further elucidation. It seems somewhat presumptuous in one who is now for the first time visiting this continent to venture to address a South African audience on local ethnology, but I share this disability with practically all students of anthropology at home, and my excuse lies in the desire that I may be able to point out to you some of the directions in which the information of anthropologists is deficient, with the hope that this may be remedied in the immediate future.

Men are naturally apt to take an exclusive interest in their immediate concerns, and even anthropologists are liable to fall into the danger of studying men's thoughts and deeds by themselves, without taking sufficient account of the outside influences that affect mankind.

In the sister science of zoology, it is possible to study animals as machines which are either at rest or in motion: when they are thus studied individually, the subjects are termed anatomy and physiology; when they are studied comparatively, they are known as comparative anatomy or morphology and comparative physiology. The study of the genesis of the machine is embryology, and palæontologists, as it were, turn over the scrap-heap. All these sciences can deal with animals irrespective of their environment, and perhaps for intensive study such a limitation is temporarily desirable, but during the period of greatest specialisation there have always been some who have followed in the footsteps of the field naturalist, and to-day we are witnessing a combination of the two lines of study.

Biology has ceased to be a mixture of necrology and physiology; it seeks to obtain a survey of all the conditions of existence, and to trace the effects of the environment on the organism, of the organism on the environment, and of organism upon organism. Much detailed work will always be necessary, and we shall never be able to do without isolated laboratory work; but the day is past when the amassing of detailed information will satisfy the demands of science. The leaders, at all events, will view the subject as a whole, and so direct individual labour that the hewers of wood and drawers of water, as it were,

shall not mechanically amass material of which no immediate use can be made, but they will be so directed that all their energies can be exercised in solving definite problems or in filling up gaps in our information, with knowledge which is of real importance.

This tendency, which I have indicated as affecting the science of zoology, is merely one phase of an attitude of mind that is influencing many departments of thought. There are psychologists and theologians who deem it worth while to find out what other people think and believe. Arm-chair philosophers are awakening to the fact that their studies have hitherto been confined almost exclusively to the most highly specialised conditions, and that in order to comprehend these fully it is necessary to study the less and the yet less specialised conditions; for it is only possible to gain the true history of mind or belief by a combination of the observational with the comparative method. A considerable amount of information has already been acquired, but in most departments of human thought and belief vastly more information is needed, and hitherto the reliability of a great deal that has been published is not above suspicion.

The comparative or evolutionary historian also needs reliable facts concerning the social condition of varied peoples in all stages of culture. The documentary records of history are too imperfect to enable the whole story to be unravelled, so recourse must be had to a study of analogous conditions elsewhere for side-lights which will cast illuminating beams into the dark corners of ancient history. When the historian seriously turns his attention to the mass of data accumulated in books of travel, in records of expeditions, or the assorted material in the memoirs of students, he will doubtless be surprised to find how much there is that will be of service to him.

Sociologists have not neglected this field, but they need more information and more exhaustive and precise analyses of existing conditions. The available material is of such importance and interest, that the pleasure of the reader is apt to dull his critical faculty; as a matter of fact, the social conditions of extremely few peoples are accurately known, and sooner or later—generally sooner—the student finds his authorities failing him from lack of thoroughness.

I have alluded to the subjects of psychology, theology, history, and sociology, because they all overlap that area over which the anthropologist prowls. Indeed it is our work to collect, sift, and arrange the facts which may be utilised by our colleagues in these other branches of inquiry, and to this extent the ethnologist is also a psychologist, a theologian, a historian, and a sociologist.

Similarly the anthropographer provides material for the biologist on the one hand, and for the geographer on the other.

As a general rule those who have investigated any given people in the field have alluded to the general features of the country they inhabit, so that usually it is possible to gain some conception of them in their natural surroundings. Thus, to a certain extent, materials are available for tracing that interaction between life and environment and between organisms themselves, to which the term œcology is now frequently applied, but we still need to have this interdependence more recognised in such branches of inquiry as descriptive sociology or religion.

Just as the arts and crafts of a people are influenced by their environment, so is their social life similarly affected, and their religion reflects the stage of social culture to which they have attained: for it must never be overlooked that the religious conceptions of a people cannot be thoroughly understood apart from their social, cultural, and physical conditions.

This may appear a trite remark, but I would like to emphasise the fact that very careful and detailed studies of definite or limited areas are urgently needed, rather than a general description of a number of peoples which does not exhaust any one of them—in a word, what we now need is thoroughness.

Three main groups of indigenous peoples inhabit South Africa:—The Bushmen, the Hottentots, and various Bantu tribes; in more northerly parts of the Continent there are the Negrilloes, commonly spoken of as Pygmies, the Negroes proper, and Hamitic peoples, not to speak of Semitic elements.

Kattea.

Before proceeding further I must here make allusion to an obscure race who may possibly be the true aborigines of Africa south of the Zambezi. These are the Kattea—or Vaalpens, as they are nicknamed by the Boers, on account of the dusty colour their abdomen acquires from the habit of creeping into their holes in the ground—who live in the steppe region of the North Transvaal, as far as the Limpopo. As their complexion is almost a pitch black, and their stature only about 1.220 m. (4 ft.), they are quite distinct from their tall Bantu neighbours and from the yellowish Bushmen. The 'Dogs,' or 'Vultures,' as the Zulus call them, are the 'lowest of the low,' being undoubtedly cannibals and often making a meal of their own aged and infirm, which the Bushmen never do. Their habitations are holes in the ground, rock shelters, and lately a few hovels. They have no arts or industries, nor even any weapons except those obtained in exchange for ostrich feathers, skins, or ivory. Whether they have any religious ideas it is impossible to say, all intercourse being restricted to barter carried on in a gesture language, for nobody has ever yet mastered their tongue, all that is known of their language being that it is absolutely distinct from that of both the Bushman and the Bantu. There are no tribes, merely little family groups of from thirty to fifty individuals, each of which is presided over by a headman, whose functions are acquired, not by heredity, but by personal qualities. I have compiled this account of this most interesting people from Professor A. H. Keane's book, 'The Boer States,' in the hope that a serious effort will be made to investigate what appears to be the most primitive race of all mankind. So little information is available concerning the Kattea that it is impossible to say anything about their racial affinities.

Perhaps these are the people referred to by Stow (p. 40), and possibly allied to these are the dwarfs on the Nosop River mentioned by Anderson; these were 1.320 m. (4 ft. 4 in.) or less in height, of a reddish-brown colour, with no forehead and a projecting mouth; Anderson's Masara Bushmen repudiated any suggestion of relationship with them, saying they were 'monkeys, not men.'

Bushmen.

The San, or Bushmen (Bosjesman of Colonial Annals), may, with the possible exception of the Kattea, be regarded as the most primitive of the present inhabitants of South Africa; according to most authors, there is no decisive evidence that there was an earlier aboriginal population, although several Bushman tales speak of previous inhabitants.

The main physical characteristics of the Bushmen are a yellow skin, and very short, black woolly hair, which becomes rolled up into little knots; although of quite short stature, with an average height of 1.529 m. (5 ft. $0\frac{1}{4}$ in.), or, according to Schinz, 1.570 m. (5 ft. $1\frac{3}{4}$ in.), they are above the pygmy limit of 1.450 m. (4 ft. 9 in.). The very small skull is not particularly narrow, being what is termed sub-dolichocephalic, with an index of about 75, and it is markedly low in the crown; the face is straight, with prominent cheekbones and a bulging forehead; the nose is extremely broad—indeed, the Bushmen are the most platyrrhine of all mankind; the ear has an unusual form, and is without the lobe. Their hands and feet are remarkably small.

Being nomadic hunters the Bushmen could only attain to the rudiments of material culture. The dwellings were portable, mat-covered, dome-shaped huts, but they often lived in caves; the Zulus say 'their village is where they kill game; they consume the whole of it and go away.' Clothing consisted solely of a small skin; for weapons they had small bows and poisoned arrows. Their only implement was a perforated rounded stone into which a stick was inserted; this was used for digging up roots. A very little coarse pottery was occasionally made. Although with a dearth of personal ornaments, they had a considerable amount of pictorial skill, and were fond of decorating their rock shelters with spirited coloured representations of men and animals. They frequently cut off the

terminal joint of a little finger. They never were cannibals. Cairns of stones were erected over graves. Although they are generally credited with being vindictive, passionate, and cruel, they were as a matter of fact always friendly and hospitable to strangers till dispossessed of their hunting grounds. They did not fight one another, but were an unselfish, merry, cheerful race with an intense love of freedom.

A great mass of unworked material exists for the elucidation of the religious ideas, legends, customs, and so forth, of the Bushmen, in the voluminous native texts, filling eighty-four volumes, to the collection of which the late Dr. Bleek devoted his laborious life. This wonderful collection of the folklore of one of the most interesting of peoples still remains inaccessible to students in the Grey Library in Cape Town. A more enlightened policy in the past would have enabled Dr. Bleek to publish his own material; now the task is complicated by the great difficulty of finding competent translators and of securing the services of reliable natives who know their own folklore. The time during which this labour can be adequately accomplished is fleeting rapidly, and once more the Government must be urged to complete and publish the life-work of this devoted scholar.

The Mañanja natives, who live south of Lake Shirwa, assert that formerly there lived on the upper plateau of the mountain mass of Mlanje a people they call Arungu, or 'gods,' who from their description must have been Bushmen. Relics of Bushman occupation have been found in the neighbourhood of Lakes Nyassa and Tanganyika. West of the Irangi plateau in German East Africa, between the steppes occupied by the Wa-Nyamwezi and the Masai, live the Wa-Sandawi, a settled hunting people who, according to Baumann, are very different from the surrounding Bantu peoples, and who are allied to the more primitive, wandering, hunting Wa-Nege, or Wa-Tindiga, of the steppes near Usukuma. They use the bow and poisoned arrow. Their language, radically distinct from Bantu, is full of those strange click sounds which are so characteristic of Bushman speech; but Sir Harry Johnston says that he does not know if any actual relationship has been pointed out in the vocabulary, and he distinctly states that the Sandawi are not particularly like the Bushmen in their physique, but more resemble the Nandi; and Virchow declares there is no relationship between the Wasandawi and the Hottentot in skull-form. Until further evidence is collected, one can only say that there may have been a Bushman people here who have become greatly modified by intermixture with other races. Sir Harry Johnston thinks that possibly traces of these people still exist among the flat-faced, dwarfish Doko, who live to the north of Lake Stephanie, and he is inclined to think that traces of them occur also among the Andorobo and Elgunono.

If the foregoing evidence should prove to be trustworthy, it would seem that at a very early time the Bushmen occupied the hunting grounds of tropical East Africa, perhaps even to the confines of Abyssinia. They gradually passed southwards, keeping along the more open grass lands of the eastern mountainous zone, where they could still preserve their hunting method of life, until, when history dawned on the scene, they roamed over all the territory south of the Zambezi.

Negrilloes.

Material does not at present exist for an exhaustive discussion of the exact relationship between the Bushmen and the Negrilloes of the equatorial forests. On the whole I am inclined to agree with Sir Harry Johnston, who says: 'I can see no physical features other than dwarfishness which are obviously peculiar to both Bushmen and Congo Pygmies. On the contrary, in the large and often protuberant eyes, the broad flat nose with its exaggerated alæ, the long upper lip and but slight degree of eversion of the inner mucous surface of the lips, the abundant hair on head and body, relative absence of wrinkles, of steatopygy, and of high protruding cheekbones, the Congo dwarf differs markedly from the Hottentot-Bushman type.' Shrubsall had previously stated: 'For the present I can only say that the data seem to me too insufficient to enable the affinities of the various pygmy races to be clearly demonstrated, or to allow of much significance being attached to any

apparent resemblance.' Deniker also draws attention to the physical characters that distinguish those two types, and he concludes that 'nothing justifies their unification.'

Hottentots.

The skin of the Hottentots, or Khoikhoi, as they style themselves, is of a brownish-yellow, with a tinge of grey, sometimes of red; the hair is very similar to that of the Bushmen; the average stature is 1.604 m. (5 ft. 3 in.); the head is small and distinctly dolichocephalic (74), the jaws prognathic, cheekbones prominent, and chin small. Shrubsall, who has investigated the osteological evidence, says no hard-and-fast line can be drawn from craniological evidence between Hottentots and Bushmen on the one hand and Negroid races on the other, various transitional forms being found; but Bushman characteristics undoubtedly predominate in the true Hottentots.

The Hottentots were grouped in clans, each with its hereditary chief, whose authority, however, was very limited. Several clans were loosely united to form tribes. Their principal property consisted of horned cattle and sheep; the former were very skilfully trained. The dwellings were portable, mat-covered, dome-shaped huts. For weapons they had a feeble bow with poisoned arrows, but they also had assagais and knobkerries, or clubbed sticks used as missiles; coarse pottery was made. They were often described as mild and amiable.

The Hottentot migration from the eastern mountainous zone took place very much later than that of the Bushmen, and it seems to have been due mainly to the pressure from behind of the waxing Bantu peoples. These pastoral nomads took a south-westerly course across the savanna country south of Lake Tanganyika, and worked their way down the west coast and along the southern shore of the continent.

What is now Cape Colony was inhabited solely by Bushmen and Hottentots at the time of the arrival of the Europeans. As the latter expanded they drove the aborigines before them, but in the meantime mongrel peoples had arisen, mainly of Boer-Hottentot parentage, who also were forced to migrate. Those of the Cape Hottentots who were not exterminated or enslaved, drifted north and found in Bushmanland an asylum from their pursuers. The north-east division of the Hottentots comprises the Koranna, or Goraqua; they were an important people, despite the fact that they had no permanent home. They migrated along the Orange River—one section went up the right bank of the Harts and the other went up the Vaal till they were deflected by the Be-Chuana. When the Boers in 1858 were engaged with the Ba-Suto, the Koranna devastated the Orange Free State, but were themselves ultimately destroyed. The original home of the Griqua was in the neighbourhood of the Olifant River; in the middle of the eighteenth century the colonists settled in the land, and as a result the Griqua-Bastards retreated to the east under the leadership of the talented Adam and Cornelius Kok. They adopted the name Griqua in place of the earlier one of Bastard; one split founded Griqua Town in Griqualand West, but the other went further east and eventually settled east of the Drakensberg, between Natal and Basutoland, and occupied the country devastated by Chaka's wars. Here rose the chief town, Kokstadt, in Griqualand East, where a few Griqua still live. The interesting little nation of the Bastards, descendants of unions between Europeans, mostly Boers, and Hottentot women, now mixes very little with other peoples. They were forced in 1868 to leave their home in Great Bushmanland owing to the ravages of Bushmen and Koranna, and finally, after various wanderings and vicissitudes, they settled as four communities in Great Namaqualand, in German territory. Namaqualand is too infertile to attract colonists, and thus it forms an asylum for expatriated Hottentots as well as for the Namaqua division of the Hottentots, the original inhabitants of the country.

True Negroes.

One of the most primitive populations of Africa is that of the true, or West African, Negroes. At present this element is mainly confined to the Sudan and the Guinea Coast.

The main physical characteristics of the true Negro are: 'black' skin, woolly hair, tall stature, averaging about 1.730 m. (5 ft. 8 in.), moderate dolichocephaly, with an average cephalic index of 74–75; flat, broad nose, thick and often everted lips, frequent prognathism.

West African culture contains some characteristic features. The natives build gable-roofed huts; their weapons include spears with socketed heads, bows tapering at each end with bowstrings of vegetable products, swords and plaited shields, but no clubs or slings. Among the musical instruments are wooden drums and a peculiar form of guitar, in which each string has its own support. Clothing is of bark-cloth and palm-fibre, and there is a notable preponderance of vegetable ornaments. Circumcision is common and the knocking out of the upper incisors. With regard to religion, there is a great development of fetishism and incipient polytheistic systems. Colonel Ellis has proved in a masterly manner the gradual evolution of religion from west to east along the Guinea Coast, and this is associated with an analogous progress in the laws of descent and succession to property, and in the rise of government. He further suggests that differences in the physical character of each country in question have played a great part in this progressive evolution. Here also are to be found secret societies, masks and representations of human figures. The ordeal by poison is employed, chiefly for the discovery of witchcraft; anthropophagy occurs. The domestic animals are the dog, goat, pig, and hen. Cattle are absent owing to the tsetse fly. The plants originally cultivated were beans, gourds, bananas, and perhaps earth-nuts. Coiled basketry and head-rests are absent.

That branch of the true Negro stock which spake the mother-tongue of the Bantu languages some 3,000 years ago (according to Sir Harry Johnston's estimate) spread over the area of what is now Uganda and British East Africa. In the Nile valley these people probably mixed with Negrilloes, and possibly with the most northerly representatives of the Bushmen in the high lands to the east. Here also they came into contact with Hamitic peoples coming down from the north, and their amalgamation constituted a new breed of Negro—the Bantu. We have already seen what are some of the more important physical characteristics of the Negro, Negrillo, and Bushman stocks; it only remains to note in what particulars they were modified by the new blood.

Hamites.

The Hamites are usually regarded as the true indigenous element in North Africa, from Morocco to Somaliland. Two main divisions of this stock are generally recognised: (1) the Northern or Western Hamites (or Mediterranean Race of some authors), of which the purest examples are perhaps to be found among the Berbers; and (2) the Eastern Hamites or Ethiopians. These two groups shade into each other, and in most places a Negro admixture has taken place to a variable extent since very early times. Perhaps these two groups should be entirely separated; the first may be allocated to the Mediterranean Race, and the second may be regarded as a mixture of Semite and Negro, to which the term Hamite might with advantage be restricted. The 'Hamites' are characterised by a skin-colour that varies considerably, being white in the west and various shades of coffee-brown, red-brown, or chocolate in the east; the hair is naturally straight or curly, but usually frizzly in the east. The stature is medium or tall, averaging about 1.670 m. (5 ft. $5\frac{3}{4}$ in.) to about 1.708 m. (5 ft. $7\frac{1}{4}$ in.); the head is sub-dolichocephalic (75–78); the face is elongated and the profile not prognathous; the nose prominent, thin, straight, or aquiline, with narrow nostrils; lips thin or slightly tumid, never everted.

Bantu.

Roughly speaking, the whole of Africa south of the equator, with the exception of the dwindling Bushman and Hottentot elements, is inhabited by Bantu-speaking peoples, who are extremely heterogeneous, but who exhibit

sufficient similarities in physical and cultural characteristics to warrant their being grouped together: the true Negro may be regarded as a race; the Bantu are mixed peoples.

It will be noticed that as a rule the Bantu approach the Hamites in those physical characters in which they differ from the true Negroes, and owing to the fact that the physical characters of Semites in the main resemble those of Hamites, any Semitic mixture that may have occurred later will tend in the same direction as that of the Hamitic. The diversity in the physical characters of the Bantu is due to the different proportions of mixture of all the races of Africa. What we now require is a thorough investigation of these several elements in as pure a state as possible, and then by studying the various main groups of Bantu peoples their relative amount of racial mixture can be determined.

The physical characteristics of the Bantu vary very considerably. The skin colour is said to range from yellowish-brown to dull slatey-brown, a dark chocolate colour being the prevalent hue. The character of the hair calls for no special remark, as it is so uniformly of the ordinary Negro type. The stature ranges from an average of about 1.640 m. (5 ft. $4\frac{1}{2}$ in.) to about 1.715 m. (5 ft. $7\frac{1}{2}$ in.). Uniformity rather than diversity of head-form would seem to be the great characteristic of the African black races, but a broad-headed element makes itself felt in the population of the forest zone and of some of the upper waters of the Nile Valley. It appears that the broadening of the head is due to mixture with the brachycephalic Negrillo stock, for, whereas the dolichocephals are mainly of tall stature, some of the brachycephals, especially the Aduma of the Ogowe, with a cephalic index of 80·8, are quite short, 1.594 m. (5 ft. $2\frac{3}{4}$ in.). The character of the nose is often very useful in discriminating between races in a mixed population, but it has not yet been sufficiently studied in Africa, where it will probably prove of considerable value, especially in the determination of amount of Hamitic or Semitic blood. The results already obtained in Uganda are most promising. Steatopygy is not notable among men; fatty deposits are well developed among women, but nothing approaching the extent characteristic of the Hottentots and Bushmen.

It appears that the Bantu peoples may be roughly divided according to culture into two groups: a western zone, which skirts the West African region or Congo basin and extends through Angola and German West Africa into Cape Colony; and an eastern zone. (1) The western Bantu zone is characterised by beehive huts, the absence of circumcision, and the presence of wooden shields (plain or covered with cane-work) in its northern portion, though skin shields occur to the south; (2) In the eastern Bantu zone, except among the Zulu peoples, the huts are cylindrical, with a separate conical roof.

Certain characteristics are typical of the Bantu culture. The natives live in rounded huts with pointed roofs; their weapons comprise spears, in which the head is fastened into the shaft by a spike, bows with bowstrings of animal products, clubs and skin shields, but slings are usually absent; the clothing is of skin and leather, and there is a predominance of animal ornaments; knocking out or filing incisors is general except in the south, circumcision is common, though among the Zulu tribes it seems to be dying out; ancestor-worship is the prevalent form of religion, fetishism and polytheism are undeveloped; masks and representations of human figures are rare, and there are no secret societies; anthropophagy is sporadic and usually temporary; the domestic animals include the dog, goat, and sheep, and cattle are found wherever possible; coiled basketry is made, and head-rests are a characteristic feature.

M. A. de Préville has drawn a broad line of distinction between the religion of the pastoral Bantu tribes and that of the hunters of the forest belt. The cattle-raisers of the small pastures recognise that the rain and necessary moisture depend on an invisible and supreme power whom they invoke in his location in the sky; his intermediaries are the rain-makers, and he has no human form, neither are there idols in the pantheon. In Central Africa there is more than sufficient rain, but rain is of little importance to the hunter. What he requires is to find game, to be able to capture it and to avoid danger; the 'medicine-men'

are not so much rain-makers, as makers of talismans, amulets, philtres, and charms to attract the game and to ensure its capture. The mysterious depths of the forest, in the impenetrable thickets of which death may lurk at each step, and the isolation which results in social disorganisation, incline the hunter to superstitious terrors. Pasturage is governed by natural impersonal forces, but hunting is individual and personal. Further, associated with the mobile pastoral life of the Bantu is the patriarchal system of family life, respect and veneration for old age, and the autocracy of the chief; no wonder, then, that ancestor-worship has developed, or that it is the chief factor in the religious life of these people, and has to a variable degree replaced the antecedent totemism.

As I have previously indicated, there is evidence of the former extension to the north of the Hottentots and the Bushmen, they having gradually been pressed first southwards and then into the steppes and deserts of South Africa by the southerly drifting of the Bantu.

The mixture of Hamite with Negro, which gave rise to the primitive Bantu stock, may have originated somewhere to the east or north-east of the Victoria Nyanza. A factor of great importance in the evolution of the Bantu is to be found in the great diversity of climate and soil in Equatorial East Africa. It is a country of small plateaus separated by gorges, or low-lying lands. The small plateaus are suitable for pasturage, but their extent is limited; thus they fell to the lot of the more vigorous people, while the conquered had to content themselves with low country, and were obliged to hunt or cultivate the land. In these healthy highlands the people multiplied, and migration became necessary; the stronger and better-organised groups retained their flocks and migrated in a southerly direction, keeping to the savannas and open country, the line of least resistance being indicated by the relative social feebleness of the peoples to the south. In the small plateaus a nomadic life is impossible for the herders, there being at most a seasonal change of pasturage; this prevents the possession of large herds and necessitates a certain amount of tillage; further, it would seem that this mode of life tends to develop military organisation and a tribal system.

No materials at present exist for any attempt at a history of this stage of the Bantu expansion, but from what we know of the great folk-wanderings in South Africa during the first half of the nineteenth century, and of the effects of the southerly migration of the Masai, we can form some estimate of what may have happened earlier in Equatorial Africa.

Lichtenstein lived among the Be-Chuana in 1805, and from that date begins our knowledge of the Bantu peoples. Dr. G. M. Theal, the learned historian of South Africa, Dr. K. Barthel, and Mr. G. W. Stow, whose valuable book has just appeared, have made most careful studies of folk-wanderings in South Africa, based upon the records of the explorers of the past hundred years; we scarcely have trustworthy accounts of the movements of the various tribes for a longer period, and oral traditions of the natives, though in the main correct, require careful handling. The nature of the country is such that it affords more than ordinary facilities for migrations, and the general absence of great geographical barriers prevents ethnical differentiation.

The Bantu peoples of Southern Africa may conveniently be classified in three main groups:—

(1) The Eastern tribes, composed of the Ama-Zulu, Ama-Xosa, &c.
(2) The Central tribes, consisting of the Be-Chuana, Ba-Suto, Ma-Shona, &c.
(3) The Western tribes, such as the Ova-Mpo and Ova-Herero.

(1) The Ama-Zulu and Ama-Xosa are respectively the northern and southern branches of a migration down the east coast, that, according to some authorities, took place about the fifteenth century. The Ama-Xosa never overstepped the Drakensberg range, but there have been northerly, and more especially southerly movements: the Ama-Xosa, for example, extended, about 1800, as far as Kaaimans River, Mossel Bay, but in 1835 they were pressed back by the colonists to the Great Fish River.

The Ama-Zulu have occupied the east coast, north of the Tugela, for a long period,

and allied tribes extend as far as the Zambezi; indeed, it may be said that a complete chain of Zulu peoples stretches up to the neighbourhood of the equator, the more open country in which they live giving greater opportunities for expansion. The wonderful rise to power of Chaka (1783–1828) caused great movements of peoples to take place. The Ama-Ngwana (who drove the Ama-Hlubi before them) and other groups fled southward to escape from the tyranny of this great warrior. The conquerors applied to these scattered remnants of tribes the contemptuous term 'Fingu,' or homeless fugitives, and turned them into slaves and cattle-tenders. The Ama-Ndabili (Matabele), to the number of some 60,000 individuals, separated from the parent stock about 1817, under the leadership of the terrible Moselekatze (Umsilikazi), whose fame as an exterminator of men ranks second only to that of Chaka; they crossed the Drakensberg and went north-west through the Transvaal, scattering the settled Be-Chuana peoples. They were attacked by the Boers, who defeated them with terrible slaughter, and withdrew to the Zambezi, but were driven south by the tsetse fly. They encountered the Ma-Kalanga (Ma-Kalaka) and destroyed their villages, drove out the Ma-Shona to the north-east, and settled in Mashonaland.

(2) The great central region of the South African plateau, roughly known as Bechuanaland, was very early occupied by Bantu peoples coming from the north, who displaced or reduced to servitude the indigenous Bushmen. As Professor Keane points out, the Be-Chuana (Ba-Choana) must have crossed the Zambezi from the north at a very early date, because of all the South Bantu groups they alone have preserved the totemic system. Among the first to arrive, according to him, appear to have been the industrious Ma-Shona and Ma-Kalanga. For three hundred years, according to native tradition, the Ma-Kalanga owned the land between the Limpopo and the Zambezi, and then came the Ba-Rotse (who appear to be allied to the Congo Bantu) and conquered them. A section of the latter founded a powerful so-called Ba-Rotse (Ma-Rotse) empire on the Middle Zambezi above the Victoria Falls. At the beginning of the nineteenth century a Ba-Hurutse dynasty ruled over the Be-Chuana; as these people expanded they broke off into clans, and extended between the Orange River and the Zambezi, and from the Kathlamba, or Drakensberg chain, to the Kalahari Desert.

The densely populated country west of the Drakensberg now known as Basutoland was subjected to great devastation as a result of Chaka's tyranny. In 1822 a tribe fleeing from the Zulus set up the first of these disturbances, and the attacked became the attackers in their turn. One horde, the Mantati (Mantiti), under the amazon Ma-Ntatesi, are credited with having wiped out twenty-eight tribes: they were eventually defeated by the Ba-Ngwaketsi and scattered by the Griqua. The Ma-Kololo, a group allied to the Mantati, led by Sebituane, in 1823 aimed at reaching the district of the Chobe and Zambezi, where he had heard that it was always spring. After conquering the Ba-Kuena, Ba-Hurutse, and other kindred tribes and increasing their forces from the conquered peoples, they crossed the Zambezi and the uplands stretching to the Kafukwe, and settled in those fertile pasture lands about 1835. Disturbed by the Matabele, Sebituane passed through the Barotse Valley, followed by the Matabele and the Ba-Toka, a tribe of the Ba-Rotse. He put the former to flight and subjugated the latter. Thus Sebituane led his people a journey of over 2,000 miles to reach their Promised Land. Under Sekeletu, Sebituane's successor, the state began to fall to pieces, and after his death the Ba-Rotse revolted, and practically exterminated the Ma-Kololo. The rehabilitated Ba-Rotse empire comprises an area of some 250,000 square miles between the Chobe and Kafukwe affluents of the Zambezi. Professor Keane draws attention to the instructive fact that though the Ma-Kololo have perished from among the number of South African tribes, their short rule (1835–1870) was long enough to impose their language upon the Ba-Rotse, and to this day, about the Middle Zambezi, where the Ma-Kololo have disappeared, their speech remains the common medium of intercourse throughout the Ba-Rotse empire. The consolidation of the Ba-Suto under the astute Moshesh is an instructive episode in the history of the South African races. The Ba-Mangwato are the most important branch of the independent Be-Chuana peoples, and have made

considerable progress under the wise guidance of the enlightened Khama; they are an industrious people, and have exceptional skill in working iron.

According to Mr. G. W. Stow (whose spelling is here adopted), there were three main migrations of the Central Bantu, or Bachoana: (i) The pioneer tribes of the southward migration into the ancient Bushman hunting grounds were the Leghoya, Bakalahari, and those who intermarried with the Bushmen to form the Balala and Bachoana Bushmen; (ii) the tribes of the second period of the Bachoana migration were the Batlapin and Barolong; (iii) the great Bakuena or Bakone tribes were the most civilised of the Bantu peoples: they consisted of the Bahurutse, Batlaru, Bamangwato, Batauana, Bangwaketse, and the Bakuena, who were the wealthiest and most advanced of all until they were reduced by the Mantati and destroyed by the Matabele.

(3) Turning for a moment to German South-west Africa we find the Bastards to the south, and north of them the Haukoin or Mountain Damara, who are now practically a pariah people, subject to the Hottentots, Bastards, Ova-Herero, and the white man. It is possible that these are of Negro rather than of Bantu origin; in mode of life, save for their talent for agriculture, they are Bushmen; in their speech they are Hottentots, but their colour is darker than that of their neighbours. Somewhere from Eastern South Africa, possibly about a hundred years ago, came the Ova-Herero, or the Merry People, who, like the rest of the Bantu, are warlike cattle-breeders, with wandering proclivities, but they are not agriculturists. When they arrived in the Kaoko district they drove the Haukoin to the south, together with the Toppnaers (Aunin) and Bushmen. To the north of the Ova-Herero are the agricultural Ova-Mpo.

Speaking generally, the direction of ethnic migration in South Africa has been southerly in the south-east: the sea blocked an eastern expansion and the Drakensberg a western; only the Matabele went westward of this range to the north. In the central district the Be-Chuana parent stock dispersed in various directions; most of the movements were towards the north, but the Mantati and Ba-Suto went south-easterly. In the west the Cape Hottentots always retreated from the colonists towards the north, the Bastards and other tribes followed the same direction, the causes, as Barthel points out, being obvious; to the east is the Kalahari, on the west is the sea, from the south came the pressure of the Boers. Finally, right across South Africa we have, from west to east, the Koranna, Griqua, and Boer wanderings in the south; and in the north, from east to west, the wanderings of the Hottentots, Ova-Herero, and recently the trek of the Boer emigrants from the Transvaal.

South Africa has thus been a whirlpool of moving humanity. In this brief summary I have been able to indicate only the main streams of movement: there have been innumerable cross-currents which add complexity to this bewildering history, and much patient work is necessary before all these complications can be unravelled and their meaning explained.

When one takes a bird's-eye view of the ethnology of South Africa, certain main sociological facts loom out amongst all the wealth of varied detail.

The earliest inhabitants of whom we have any definite information were the dwarf Bushmen, who undoubtedly represent a primitive variety of mankind. In a land abounding with game they devoted themselves entirely to the chase, supplementing their diet with fruit and roots. This mode of life necessitates nomadic habits, the absence of property entails the impossibility of gaining wealth, and thereby relieving part of the population from the daily need of procuring food; this absence of leisure precludes the elaboration of the arts of life. A common effect of the nomadic hunting life is the breaking-up of the community into small groups; the boys can soon catch their own game, hence individualism triumphs and parental authority is apt to be limited. Social control is likely to be feeble unless the religious sentiment is developed, and certainly social organisation will be very weak. In an open country abounding with game the case is somewhat different, and there is reason to believe that in early days the Bushmen were

divided into a number of large tribes, occupying tolerably well-defined tracts of country, each being under the jurisdiction of a paramount chief. The tribes were subdivided into groups under captains. They showed great attachment and loyalty to their chiefs, and exhibited a passionate love for their country. For hundreds of years these poor people have been harried and their hunting grounds taken away from them, and hence we must not judge the race by the miserable anarchic remnant that still persists in waste places. Nomad hunters do not progress far in civilisation by their own efforts, nor are they readily amenable to enforced processes of civilisation. Invariably they are pushed on one side or exterminated by peoples higher in the social scale.

When the written history of South Africa begins we find the Bushmen already being encroached upon by the Hottentots, who themselves sprang from a very early cross of Hamite with Bushmen. Culturally, as well as physically, they may be regarded as a blend of these two stocks. They combined the cattle-rearing habits of the Hamite with the aversion from tillage of the soil characteristic of the hunter; they became nomadic herders, who were stronger than the Bushmen, but who themselves could not withstand the Bantu when they came in contact with them, and they too were driven to less favourable lands and became enslaved by the invaders. All gradations of mixture took place till lusty uncontaminated Bantu folk forced their way into the most desirable districts. Still less could the Hottentots prevail against the colonists; their improvidence was increased by alcohol, and their indifference to the possession of land, due to their inherent love of wandering, completed their ruin.

The Bantu were cattle-rearers who practised agriculture. The former industry probably was transmitted from their Hamitic forefathers, who were herdsmen on the grassy uplands of north-eastern Africa, while the latter aptitude was probably due in part to their negro ancestry. This duality of occupation led to variability in mode of life. In some places the land invited the population towards husbandry, in others the physical conditions were more suited to a pastoral life, and thus we find the settled Ba-Ronga on the one hand and the wandering Ova-Herero on the other. The Bantu peoples easily adopt changes of custom; under the leadership of a warlike chief they become warlike and cruel, a common characteristic of pastoral peoples, while it is recorded that many of the Matabele, taken prisoners by the Ba-Rotse, settled down peacefully to agriculture. The history of the prolific Bantu peoples on the whole indicates that they were as loosely attached to the soil as were the Ancient Germans, and like the latter, at the slightest provocation, they would abandon their country and seek another home. This readiness to migrate is the direct effect of a pastoral life, and along with this legacy of unrest their Hamitic ancestors transmitted a social organisation which lent itself to discipline. These were the materials, so to speak, ready to hand when organisers should appear. Nor have such been lacking, for such names as Dingiswayo, Chaka, Dingan, Moselekatze, Lobengula, Moshesh, Sebituane, Cetewayo, and others are writ large in the annals of South Africa; and the statesman Khama is an example of what civilisation can do to direct this executive ability into proper channels.

Archæology.

The archæology of South Africa is now attracting considerable local interest, and we may confidently expect that new discoveries will soon enable us to gain some insight into the dense obscurity of the past. It cannot be too strongly insisted upon that the methods of the archæologist should be primarily those of the geologist. Accurate mapping of deposits or localisation of finds is absolutely necessary. The workmanship of an implement is of little evidential value: the material of which it is made may be refractory, the skill of the maker may be imperfect, or he may be satisfied with producing an implement just sufficient for his immediate need; and there is always a chance that any particular specimen may be simply a reject. The early generalisation of implements in England into two groups, Palæolithic and Neolithic, expressed a fact of prime importance, but now the classification has extended. It is obvious that the shapely palæoliths of the

older gravels could not have been the first attempts at implement making by our forefathers, and the presumed hiatus between the two epochs has been bridged over by evidence from sites on the European mainland. Our knowledge is increasing apace and an orderly sequence is emerging, but there are many interesting variations, and even apparent setbacks, in the evolution of industrial or artistic skill. In a word, sequence and technique must not be confounded, and our first business should be to establish the former on a firm basis; but, as I have just remarked, this can be accomplished only by adhering rigidly to the stratigraphical methods of the geologist. It would probably be to the interest of South African archæology if the terms 'Eolithic,' 'Palæolithic,' and 'Neolithic' were dropped, at all events for the present, or restricted solely to type of technique; and it might prove advantageous if provisional terms were employed, which could later on be either ratified or abandoned, as the consensus of local archæological opinion should decide.

In certain lands of the Old World, north of the Equator, there was a progressive evolution from the Stone Ages, through a copper and a bronze age, to that of iron; but the stone-workers of South Africa appear to have been introduced to iron-smelting without having passed through the earlier metal phases, since the occurrence of copper implements is too limited to warrant the belief that it represents a definite phase of culture. The similarity of the processes employed in working iron by the different tribes of Africa, south of the Equator, indicates that the culture was introduced from without, a conclusion which is supported by the universal use of the double bellows—a similar instrument is in use in India and in the East Indian Archipelago. Some ethnologists hold that Africa owes to India its iron industry and other elements of culture, as well as the introduction of the ox, pig, and fowl. At all events, we shall probably not be far wrong if we assign a fair degree of antiquity to the knowledge of iron in tropical and southern Africa.

The characteristic metal of South Africa is gold, and its abundance has had a profound effect on the country. We cannot tell when it was first discovered or by whom, but the hundreds of ruins scattered over a large extent of country, and the very extensive ancient workings, testify to the importance and the long continuance of this industry. It is greatly to be deplored that in the past irresponsible prospectors have been permitted to rifle the ancient ruins for gold, with the result that not only have very numerous specimens of archæological interest been cast into the melting-pot, but at the same time collateral evidence has been destroyed, and thus valuable data lost to science. Even now the situation is not without its dangers, for the recently awakened interest in the ruins, and appreciation of their historical value, may lead to unconsidered zeal in excavation. After all, there is no especial hurry; what is perishable has long ago decayed, and so long as the ruins are sealed up by the rubbish that preserves them, no great harm can accrue, but a few hours of careless excavation may destroy more archæological evidence than centuries of neglect. Therefore it would be advisable for those in authority to consider carefully whether it is wise to lay bare new sites, unless proper examination and preservation can be ensured. The number of the ruins in Rhodesia is so great, and the area within which they occur so enormous, that it would be a very large undertaking for the Government systematically to investigate and permanently to conserve them all. Perhaps it would be possible to entrust some of this work to properly constituted local authorities, assisting them by grants and special facilities, but care would have to be taken to ensure the thorough carrying out of the work. Records of work done should be published, and the specimens preserved in authorised museums only. It is desirable also that every ruin should be scheduled under an Ancient Monuments Protection Act, and that an Inspector or Curator of Ancient Monuments should be appointed, who would be responsible for the excavation and preservation of all the monuments. To a less extent these remarks apply also to other parts of South Africa. All relics of the past, such, for example, as the pictographs in the rock-shelters of the Bushmen, should be jealously preserved and guarded from intentional or unwitting injury.

I trust my South African colleagues will forgive me if I have appeared too much in the character of a mentor. I have endeavoured to present a general

view of the anthropological situation in South Africa, without burdening my remarks with details, and at the same time I have made bold to publish some of the conclusions which this survey has suggested; but there are other points on which I feel constrained to touch.

Recently Sir Richard Temple delivered an Address on 'The Practical Value of Anthropology,' in the course of which he said: 'We often talk in Greater Britain of a "good" magistrate or a "sympathetic" judge, meaning thereby that these officials determine the matters before them with insight; that is, with a working anthropological knowledge of those with whom they have to deal. . . . It is, indeed, everything to him to acquire the habit of useful anthropological study before he commences, and to be able to avail himself practically and intelligently of the facts gleaned, and the inferences drawn therefrom, by those who have gone before him. . . . Take the universally delicate questions of revenue and taxation, and consider how very much the successful administration of either depends on a minute acquaintance with the means, habits, customs, manners, institutions, traditions, prejudices, and character of the population. In the making of laws too close a knowledge of the persons to be subjected to them cannot be possessed, and however wise the laws so made may be, their object can be only too easily frustrated if the rules they authorise are not themselves framed with an equally great knowledge, and they in their turn can be made to be of no avail unless an intimate acquaintance with the population is brought to bear on their administration. For the administrator an extensive knowledge of those in his charge is an attainment, not only essential to his own success, but beneficial in the highest degree to the country he dwells in, provided it is used with discernment. And discernment is best acquired by the "anthropological habit." . . . The habit of intelligently examining the peoples among whom his business is cast cannot be overrated by the merchant wishing continuously to widen it to profit; but the man who has been obliged to acquire this kind of knowledge without any previous training in observation is heavily handicapped in comparison with him who has acquired the habit of right observation, and, what is of much more importance, has been put in the way of rightly interpreting his observations in his youth.'

In referring to civil-servants, missionaries, merchants, or soldiers, Sir Richard Temple went on to say: 'Sympathy is one of the chief factors in successful dealings of any kind with human beings, and sympathy can only come with knowledge. And not only does sympathy come of knowledge, but it is knowledge that begets sympathy. In a long experience of alien races, and of those who have had to govern and deal with them, all whom I have known to dislike the aliens about them, or to be unsympathetic, have been those that have been ignorant of them; and I have never yet come across a man who really knew an alien race that had not, unless actuated by race-jealousy, a strong bond of sympathy with them. Familiarity breeds contempt, but it is knowledge that breeds respect, and it is all the same whether the race be black, white, yellow, or red, or whether it be cultured or ignorant, civilised or semi-civilised, or downright savage.'

I have quoted at length from Sir Richard Temple, as the words of an administrator of his success and experience must carry far greater weight than anything I could say. I can, however, add my personal testimony to the truth of these remarks, as I have seen Britons administering native races on these lines in British New Guinea and in Sarawak, and I doubt not that I shall now have the opportunity of a similar experience in South Africa.

In this connection I ought to refer to what has been already done in South Africa by the Government. In the year 1880 the Government of Cape Colony, confronted by the problem of dealing with the natives, appointed a Commission to inquire into the native laws and customs which obtained in the territories annexed to the Colony, especially those relating to marriage and land-tenure, and to suggest legislation, as well as to report on the advisability of introducing some system of local self-government in the native territories annexed to the Colony. The example was shortly afterwards followed by the Government of Natal, which had native problems of its own. These two Commissions collected and published a considerable amount of evidence, valuable not only for the immediate purpose in view, but

also for the purposes of science. Before the late war came to a close the Anthropological Institute of Great Britain and Ireland and the Folklore Society addressed to Mr. Chamberlain, then Colonial Secretary, a memorial praying that on the conclusion of peace a similar Commission should be issued to inquire into the customs and institutions of the native tribes in the Transvaal and the Orange River Colony, and, with a view to the accomplishment of more directly scientific ends, praying that at least one anthropologist of eminence unconnected with South Africa should be included in the Commission. The prayer of the Memorialists was bluntly refused. When, however, in the course of reorganisation of the administration, a conference was held at Bloemfontein in 1902 of the Ministers of the various colonies, protectorates, and territories, to discuss native affairs, they found themselves, in the words of Sir Godfrey Lagden, 'much confused because the laws and the conditions of all the colonies were different.' This was exactly what the Memorialists had told Mr. Chamberlain. So the conference determined on the appointment of a Commission of Inquiry, which was issued in due course by Lord Milner in September 1903, and reported on January 30 last. The evidence taken by this Commission, as well as that taken by the previous Commissions, is of a very valuable character. But, like those Commissions, its object was exclusively administrative. Consequently the evidence is only incidentally of ethnological interest, and it by no means covers the whole ground. The social life and marriage laws are to a great extent laid before the reader, but there is no attempt to distinguish accurately between one tribe and another; the native institutions are discussed only so far as they have a practical bearing on administrative questions. There is no attempt to penetrate to the underlying ideas and beliefs, and the vast domain of religion lies for the most part outside the ken of the Commissioners. Admirable, therefore, as is the work done by these Commissions, it is but a small part of what must be undertaken if an accurate account of the natives of South Africa is to be obtained and preserved for scientific use, and as an historical record. What is wanted is that the Government should undertake this enterprise in the same way as that in which the Governments of the United States, Germany, the Netherlands, and of other countries investigate their native races, or, failing this obvious duty of a Government, adequate assistance should be given to societies or individuals who may be prepared to take the matter in hand.

Unfortunately it is not unnecessary to insist on the need there is for us to consider seriously what at any particular time is most worth investigating, and not to let ourselves drift into any casual piece of work. Let us apply that simple test to South Africa, and ask ourselves, What most needs doing in anthropological research in South Africa?

So long as actual wanton destruction is not taking place, local archæological investigation can wait. I do not mean to suggest that those who have the opportunity should not devote themselves to this important subject; many can do good work in archæology who have neither opportunity nor inclination for other branches of anthropology, and the British South Africa Company has shown and probably will continue to show a real interest in this work. But our first and immediate duty is to save for science the data that are vanishing; this should be the watchword of the present day.

Observations in South African anthropography are lamentably deficient. Although scattered up and down in books of travel and in missionary records, there are descriptions of individuals, and in some cases a few salient features of a tribe are noted, yet we have few precise descriptions of communities that are of value for comparative purposes. Anthropometrical data are everywhere wanting; very few natives have been measured, and the measurements that have been made are insufficient both as regards those actually taken and the number of individuals measured. The interesting subject of comparative physiology is unworked. We have no observations in experimental psychology, and very few reliable data in observational psychology. Here, then, is a large field of inquiry.

I am not competent to speak concerning linguistics, but from what I have

read I gather that a very great deal yet remains to be done, at all events in phonetics, grammar, and comparative philology.

In general ethnology a considerable amount of scattered work has been done, but no one tribe has been investigated with scientific thoroughness; the best piece of work hitherto accomplished in this direction is the admirable memoir on the Ba-Ronga by the missionary H. A. Junod, which leaves little to be desired. It would be well worth while for students to make exhaustive studies of limited groups of people, tracing all the ramifications of their genealogies in the comprehensive method adopted by Dr. Rivers for the Torres Straits Islanders and for the Todas; this method is indispensable if it is desired to obtain a true conception of the social structure of a people, their social and religious duties, the kinship relationships, and other information of statistical and sociological value. Other fruitful lines of inquiry are the significance of the form and ornamentation of objects and the symbolism (if there is any) of the decorative art, a subject which, as far as I am aware, is absolutely untouched. Even the toys and games are worth investigation. Hardest but most important of all, there is that intricate complexus of action and belief which is comprised under the term 'religion.' This needs the most delicate and sympathetic treatment, although too often it has been ruthlessly examined by those who were more prone to seek the ape and the tiger and vain imaginings in the so-called 'superstitious' practices of these poor folk. They are laggards along the road which our more favoured ancestors have trod, but they all have their faces set in the same direction as our own, towards that goal to which we ourselves are striving. To induce natives to unbosom themselves of all that they hold secret and sacred and to confess their ideals and inspirations requires more than an ordinary endowment of patience, tact, and brotherly kindness; without these qualities very little can be gathered, and the finer side of native thought and feeling will for ever remain a sealed book to the European. In referring to this subject it should not be overlooked that the best account we have of the religion of the Ama-Zulu is due to the labours of Bishop Callaway. The number of native texts, including folk-tales, published by him are especially valuable, as they throw light from all sides upon the native mind, and it is greatly to be regretted that he lacked the pecuniary and other encouragement that was necessary for the completion of his labours. The most urgent of all the foregoing lines of inquiry are the most elusive: these are the ideas, beliefs, and institutions of the people, which are far less stable than are their physical characteristics.

These are some of the lines of research that await the investigator. The field is large, but the opportunities are fleeting. The Kattea, Bushmen, and Hottentots are doomed, and new social conditions are modifying the Bantu peoples. Here again we must apply the test question, Which of these peoples most needs investigation? The answer again is obvious. Those that will disappear first. All over South Africa this work is pressing. For some tribes it is too late. It would be a memorable result of the meeting of the British Association in South Africa if it should lead to an exhaustive study of those most interesting people, the Kattea, the Bushmen, and the Hottentots. They represent very primitive varieties of mankind, but their numbers are rapidly diminishing, and, as races, they have no chance of perpetuity. What judgment will posterity pass upon us if, while we have the opportunity, we do not do our best to save the memory of these primitive folk from oblivion?

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The foregoing list of books is manifestly very incomplete. A considerable

amount of information concerning the natives will be found in numerous books by missionaries, travellers, and sportsmen.

Since the above was in print Professor G. Elliot Smith has investigated six Pygmies from the Ituri Forest in the Congo Free State. He states, 'When we take into consideration the many undoubted resemblances of Pygmies and Bushmen it is easier to picture these likenesses and their attendant differences as the results of a diverse specialisation of two branches of one stock rather than as the product of a tendency to convergence of two independent races.'[1]

Mr. D. Randall-MacIver, who was sent out in advance of the British Association to investigate the ancient ruins of Rhodesia, has found that the archæological evidence points to their being of mediæval date; his investigations and conclusions will be recorded in his forthcoming book, 'Mediæval Rhodesia.'

The following Papers were read:—

1. *The Totemism of the Bantu.* *By* E. Sidney Hartland.

Totemism is the reverence for, and the recognition of kinship with, certain objects or classes of objects of external nature, such as a species of animal, a species of tree or plant, or (more rarely) the sun or rain. This reverence and recognition of kinship arise only in savagery, and are expressed in certain definite rites and observances. The phenomena of totemism were first observed among the North American Indians, and the name is derived from a native American word. Similar phenomena have subsequently been observed elsewhere, notably among the Australian blackfellows. M. Casalis pointed out fifty years ago the similarity between the practices and beliefs of the Bantu and the American natives. The object of the paper is to examine the Bantu practices and belief with a view to ascertaining:—

1. How far they extend, and what evidence there is of their former existence where they are no longer to be found.
2. Whether there is any essential difference between the Bantu practices and belief, and what is generally understood by totemism elsewhere.
3. The process of decay, especially among the Eastern Bantu from the Zambesi southward.

The conclusions arrived at are that though there is little in what is recorded of the Western Bantu which points directly to totemism, there is reason to think that it once generally prevailed among the Bantu; that its disappearance from the Western Bantu is due to contact with the true Negro along the west coast; that among the Eastern and Northern Bantu the decay of totemism is due to the change in the reckoning of kinship from reckoning through the mother only to reckoning through the father, and to the ancestor-worship which has arisen upon the new social basis thereby laid; and that there is no essential difference between the Bantu practices and belief and what is generally recognised as totemism elsewhere.

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2. *The Stone Age in South Africa.* *By* L. Péringuey.

The author recognises two periods in South Africa. To the latter, which he terms 'Recent,' he ascribes all the implements found in the middens of the sea-coast as well as inland; to the former the weapons or implements, often of a huge size, which partake so much of the facies of the palæolithic instruments met with in the laterite deposits of Madras or the Pyrenees that they are hardly distinguishable, some of them weighing as much as 9½ lbs. and being 34 cm. long by 17 cm. wide. It is contended that implements of that kind could not have been used by a small, puny race like that of the Bushmen, yet on the whole the author is of opinion that

[1] *Lancet*, August 12, 1905, p. 430.

a great age cannot be ascribed to them. These he considers to belong to a palæolithic type. He is also of opinion that a neolithic period was evolved from that palæolithic one, but was superseded by a more barbaric, more recent one, *i.e.*, by that of the 'Recent' age. There is, however, no evidence as to the epoch when one period replaced the other, and, as far as the implements of a palæolithic type are concerned, neither geology nor palæontology has as yet enabled us to assign a possible age to these implements. They abound, however, where they occur, and they have undoubtedly been brought down to their present situation from their once much more elevated position, and have thus accumulated on the lower part of the mountain talus. The hardest kind of stone available has always been made use of.

But if no evidence as to the age of that palæolithic type is to be obtained, there is ample evidence that that of the 'Recent Period' ended only yesterday. Not only are these implements of a crude type, and always worked only on one side, with the bulb of percussion always strongly bulging, but evidence of this period being quite recent was proved by the finds of a club, made, it is true, of a very lasting wood, and bearing unmistakable traces of having been cut into shape by a stone implement; of diminutive models of a gun and spade cut out with minute flakes and found in a Bushman's lair; and also of one of these crude stone implements fixed by gum to a small wooden handle, somewhat in the manner of the Australian aborigines, and dug out from one of the caves on the coast with the skeleton of a Strand-Looper Hottentot, &c. Mention was also made, and examples exhibited, of the mullers and pounders, scrapers, knives, or arrow-heads found in the middens of the coast or its vicinity.

But on the Cape Flats are occasionally found lance or arrow heads of a very superior workmanship, chipped on both sides and tapering at both ends into a point, which will bear successful comparison with any of the Dordogne implements of that kind. At Vereeniging, in the Transvaal, implements also pointed at both ends have been met with, but although they are of a different workmanship, they, like those of the Cape Flats, would seem to imply that they belong to a neolithic type, having nothing in common with the 'Recent Period.'

THURSDAY, AUGUST 17.

The following Papers and Reports were read:—

1. *The Musical Instruments of South Africa.* *By* HENRY BALFOUR, *M.A.*

The various musical instruments made and used by the African natives inhabiting the region to the south of the 15th parallel of S. latitude, present many points of interest, and afford an ample field for careful research. Several of the types are of value to the student of the early developmental history of musical instruments, as being *survivals* from the original rudimentary forms, or archetypes, whence have arisen by successive improvements a long line of descendants, culminating in certain highly specialised forms of modern civilised instruments. The bow of the Damaras, which is *temporarily* converted into a musical instrument, may be cited as a survival from the earliest stage in the history of a group. In it we may recognise the ancestral form whence may be traced through a long and more or less continuous main line of development, which embraces the musical bows and their derivatives, the phylogenetic history of that series of instruments which, by successive slight modifications, led up to the final developments of the harp family.

Many instruments are interesting not only by reason of the light which, as links in the chain of sequence, they throw upon the probable evolution of the higher forms from the more rudimentary, but also when studied from the point of view of their *geographical distribution,* whereby conclusions may be arrived at in regard to the question of the *monogenesis* or *polygenesis* of certain types—as to

whether, that is to say, forms which are practically similar, occurring in widely separated regions, are referable to a common origin, or whether they have been independently invented in the various regions in which they are found. From this point of view the musical-bow series and the xylophone (*marimba*) group are of special interest, as illustrating in each case what may prove to be a phylogenetically connected series covering a very wide area of dispersal both within and without the African continent.

The pulsatile instruments with vibrating tongues of bamboo or metal (*sansa* type) present a very wide and continuous distribution in Africa, but do not appear to occur elsewhere, except in the regions of the new world which have been affected by the negro immigration; nor does this form of instrument appear to have led up to any highly developed type, unless the graduated 'comb' of European musical boxes, which presents at least a close analogy, is to be regarded as a derivative from the African *sansa*, a matter which is open to doubt.

The 'whizzing-blade,' or, to give its popular name, the 'bull-roarer' of the Bushmen and some Bantu tribes, is noticeable for its extremely wide though sporadic distribution over the world, as also by virtue of the mystery which either has been or is so constantly associated with the use of this simple instrument wherever it occurs; and the question arises whether all these nearly identical forms have been derived from a common stock, which must be of very great antiquity to account for their wide dispersal from a single centre, or whether the theory of two or more independent origins is the more probable.

The noise-instrument known to the Germans as reib-trommel ('rubbing-drum'), and described by Holub as found in use among the Barotse, is another instrument having a peculiarly wide though apparently disconnected distribution. It has its counterparts in some other regions of Africa, both east and west; it is met with in Southern India, in Honduras, and Venezuela, and is a popular noise-making instrument in Western Europe, where it was known as far back as early in the seventeenth century, and probably earlier.

The *goura* of the Bushmen and *iseba* (*lesiba*) of the Basuto and some other Bantu tribes, a bow-like instrument having a piece of flattened quill interposed between one end of the string and its attachment to the bow, is difficult to diagnose ethnologically and morphologically. In spite of its stringed structure it is essentially a *wind* instrument. Its presence in South Africa has not as yet been satisfactorily accounted for, since there is an absence of evidence as to the manner in which this peculiar and specialised instrument was developed in this region, supposing it to be indigenous; nor are there any satisfactory clues as to whence it came, in the event of its having been introduced from elsewhere. It does not appear to be found anywhere north of the Zambesi. The instruments which in structure and use most nearly resemble the *goura* are the small bows with flat, ribbon-like strings, which in Eastern Asia are attached to kites in order that they may hum or buzz in the wind; but it is by no means clear that these are to be regarded as morphologically related to the *goura*. It is to be hoped that further detailed research into the varieties and distribution of types of the ruder musical instruments may help to render clearer their affinities, and the precise position which they occupy in the developmental history of higher forms.

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2. *A Few Facts concerning the American Negro.* *By* Miss B. Pullen-Burry.

In this paper an attempt was made to show that notwithstanding their transplantation to the Western Hemisphere, the hardships of 250 years of slavery, their ignorance when emancipated, and their incapacity to assimilate such civilisation as is implied in American citizenship, the Negroes now form one-seventh of the entire population of the United States. Statistics of 1900 show the race to exist in greatest density in the territory known as 'The Black Belt.' The injurious effects of urban life on the Negro are evidenced by information obtained from the Health Officer of Washington, D.C. The Negro's criminal record, declared to be greater

at the North than at the South, is answered by the fact that in northern cities his expulsion, owing to race-prejudice, from almost every competitive trade makes it increasingly difficult to earn a livelihood. In fifty-six great cities statistics show a greater death-rate than birth-rate, but on the cotton-fields in the South, where the Negro is gradually attaining proprietorship, he lives normally. Outside cities, 85 per cent. of the race depend upon agriculture for support. Prevailing diseases, crime, with some details as to lynching, the economic status of the race, &c., were also dealt with.

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3. *Report on Anthropometric Investigation in the British Isles.* See Reports, p. 198.

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4. *Report on Anthropometric Investigations among the Native Troops of the Egyptian Army.*—See Reports, p. 207.

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5. *Report on Anthropological Photographs.*—See Reports, p. 222.

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6. *Report on the Age of Stone Circles.*—See Reports, p. 197.

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7. *Report on Archæological and Ethnological Researches in Crete.* See Reports, p. 208.

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8. *Report on the Lake Village at Glastonbury.*—See Reports, p. 210.

FRIDAY, AUGUST 18.

The following Papers were read:—

1. *On Artificial Deformation of the Human Body in Africa.* *By* Professor Dr. F. VON LUSCHAN.

Probably most of the deformations of the ears and the nose came to Africa from India; the painting of the eyes came from Arabia; and the trepanning of the skull (practised up to our own days in Djebil Aurès in the same way as it was practised by the old Guanches) is the same as that of the earliest prehistoric inhabitants of the Dordogne, and had its origin in Western Europe. Most, if not all, of the deformations and mutilations of the teeth seem to come from Indonesia, even those practised in the Western Soudan. Only the tattooing in relief, and perhaps also the deformations of the lips, might be at home in Africa.

The whole study of artificial deformations is not only an interesting scientific speciality on the frontier boundaries between ethnography and physical anthropology, but it may be of some importance also for the ultimate problem of anthropology—for the history of mankind.

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2. *The Mental Capacity of the Bantu.* *By* Rev. Canon CRISP.

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3. *Magato and his Tribe.* *By* WILLIAM GRANT

JOHANNESBURG.

TUESDAY, AUGUST 29.

The following Papers were read:—

1. *Arts and Crafts among the Natives of South Africa.* *By* Dr. S. Schonland.

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2. *Bushmen and their Art.* *By* W. A. Squire.

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3. *Stone Implements in South Africa.* *By* J. P. Johnson.

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4. *The Basuto.* *By* H. E. Mabille.

WEDNESDAY, AUGUST 30.

The following Papers were read:—

1. *The Last South African Potentate: Gugunhana.* *By* Dr. Liengme.

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2. *The Racial Affinities of the Hottentots.* *By* Professor Dr. F. von Luschan.

The Hottentot is an Hamitic language. In particular its grammar is strictly Hamitic, and only a few roots and a few clicks have been adopted from the Bushmen, just as some of the Southern Bantu languages have adopted clicks in the last few centuries. On the other hand, the Hamitic forefathers of the Hottentots lost their high stature and acquired steatopygia and spiral curled hair by intermarriage with Bushmen, probably many thousands of years ago.

Bushman languages seem to be related with the languages of the Western Soudan, and perhaps also with some languages of the far east of Asia.

Westermann was the first to show the isolating character of, and the importance of studying syllabic intonation varying in the Soudanic languages, just as, *e.g.*, in the Chinese. All the Pygmy races of Tropical Africa seem to be closely related to the Bushmen, but their languages have not yet been studied well enough to enable their exact relations to be determined. Their connection with the Pygmies of Southern Asia is also very probable.

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3. *Ruins in Rhodesia.* *By* D. Randall-MacIver. See p. 301.

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4. *Exhibition of Stone Implements from Zambesi.* *By* G. W. Lamplugh, *F.R.S.*

FRIDAY, SEPTEMBER 1.

The following Papers were read:—

1. *The Bawenda.* *By* Rev. E. GOTTSCHLING.

2. *The Thonga Tribe.* *By* Rev. A. H. JUNOD.

3. *Notes on the Totemism of the Becwana.* *By* Rev. W. C. WILLOUGHBY.

4. *The Native Tribes of South Africa.* *By* J. W. SHEPSTONE, *C.M.G.*

5. *Native Circumcision Lodges.* *By* C. A. WHEELWRIGHT, *C.M.G.*

Section I.—PHYSIOLOGY.

President of the Section—Colonel D. Bruce, C.B., M.B., F.R.S.

The President delivered the following Address at Johannesburg on Tuesday, August 29:—

The Advance in our Knowledge of the Causation and Methods of Prevention of Stock Diseases in South Africa during the last ten years.

Ten years ago, when I first came to South Africa, I was led to take an interest in the various great stock diseases which do so much damage and so retard the progress of South Africa as a stock-raising country. I thought, therefore, that a good subject for my address, in the centre of the foremost stock-raising Colony of South Africa, would be a review of the work done in advancing our knowledge, during the last ten years, of the causation and methods of prevention of stock diseases in South Africa.

South Africa is particularly rich in animal diseases, every species of domestic animal seemingly having one or more specially adapted for its destruction. Now it is evident that, in an address of this kind, it will be impossible to take up every stock disease, but I think you will agree with me that those shown on this table are among the most important:—

East Coast Fever; ordinary Redwater or Texas Fever; Biliary Fever of Horses; Malignant Jaundice of Dogs; Nagana or Tsetse-fly Disease; Trypanosomiasis of Cattle; Rinderpest; Horse-sickness; Catarrhal Fever in Sheep; Heart-water of Sheep, Goats, and Cattle.

Now we may group these diseases in various ways; for example, as below, where they are divided into two main divisions: *A* division, in which the parasite is known; and *B* division, in which the parasite is unknown.

A. Parasite known.

I. Diseases caused by parasites belonging to the genus Piroplasma:—

1. East Coast Fever (Koch), *P. parvum.*
2. Redwater or Texas Fever, *P. bigeminum* (Theiler).
3. Biliary Fever of Horses, Mules, and Donkeys, *P. equi.*
4. Malignant Jaundice of Dogs, *P. canis.*

II. Diseases caused by parasites belonging to the genus Trypanosome:—

1. Nagana or Tsetse-fly Disease, *T. brucei* (Bradford and Plimmer).
2. Trypanosomiasis of Cattle, *T. theileri* (Bruce).

B. Parasite unknown.

I. Rinderpest.
II. Horse-sickness.

Catarrhal Fever of Sheep.
Heart-water of Sheep, Goats, and Cattle.

I. Diseases caused by Parasites belonging to the Genus Piroplasma.

1. *East Coast Fever.*

The first important stock disease I would draw your attention to, then, is East Coast Fever. This name was given to it by Professor Robert Koch, of Berlin. In the Transvaal the disease is usually called Rhodesian Redwater. This term is not a good one, since the disease is not restricted to Rhodesia, nor did it arise there, nor is this a disease similar to the ordinary Redwater. Ten years ago, when I first came to South Africa, East Coast Fever was unknown in the Transvaal. The first known outbreak occurred only some three and a half years ago, when it broke out at Koomati and Neilspruit, in the Barberton district, and in the east of the Colony. The disease had broken out some time previously in Rhodesia, and the outbreaks in both Colonies were due to infection from Portuguese territory. Although this disease has only been introduced to the country during the last few years, it has already produced an enormous amount of damage among stock, and is probably the most dangerous disease that the people of the Transvaal have to cope with at the present time, and for some years to come.

In the Annual Report of the Transvaal Department of Agriculture there is a most excellent report by Mr. Stockman, the then Principal Veterinary Surgeon, on the work of the veterinary division for the year 1903–1904. A large part of this report is given up to East Coast Fever, and I must here express my indebtedness to Mr. Stockman for much of the following account of this disease. In the same Annual Report there is also an account by Dr. Theiler, the Veterinary Bacteriologist, of the experimental work. Messrs. Stockman and Theiler evidently worked together, and I must congratulate them on the immense amount of good, useful work done by them, and I would also congratulate the Government on having had the services of two such accomplished and energetic gentlemen during the late troublesome times. Unfortunately for the Transvaal, Mr. Stockman has accepted the post of Veterinary Adviser to the Board of Agriculture in England, but I have no doubt his successor, Mr. Gray, from Rhodesia, will continue the good work begun by him.

East Coast Fever was first studied by Professor Koch at Dar-el-Salaam, in German East Africa, and he at first mistook it for ordinary Redwater. It seems to occur as an endemic disease along a great part of the East Coast of Africa, but appears to be restricted to a narrow belt along this coast-line. The cattle inhabiting this region have become immune to the disease, and are, therefore, not affected by it. Cattle passing through the Coast district to the interior, or brought to the Coast district from the interior, are apt to take the disease and die. It was by the importation of cattle, therefore, which had passed through the dangerous Coast district that the disease was introduced into Rhodesia and into the Transvaal. On this map which I throw on the screen I have marked out the probable endemic area of this disease, and in the next slide the present distribution of the disease in the Transvaal is also marked out.

Nature of the Disease.—This disease only attacks cattle, but in them is an exceedingly fatal malady: in every hundred cattle attacked only about five recover from the disease. The duration of the disease after the first symptoms have occurred is about ten days.

The cause of the disease is a minute blood parasite called the *Piroplasma parvum* (Theiler). This parasite lives in the interior of the red blood corpuscles.

I now throw on the screen a representation of the blood from a case of Rhodesian Redwater, magnified about a thousand times, showing these small piroplasmata in the interior of the red blood corpuscles. As in the case of so many of these blood diseases, the parasite causing it is carried from the sick to the healthy by means of a blood-sucking parasite. In this particular disease the tick

which most commonly transfers the poison or living parasite from one animal to another is known as the 'brown tick,' *Rhipicephalus appendiculatus.* Koch supposed that the common 'blue tick' was the agent. The credit belongs to Dr. Lounsbury and Dr. Theiler of having shown that it is chiefly the 'brown tick' which acts as carrier; but Theiler has proved that *R. simus* is also able to transmit the disease. Without the intervention of a tick, as far as we know at present, it is quite impossible that the parasite of this disease can be transferred from one animal to another. For example, if we take a quantity of blood containing enormous numbers of these piroplasmata, and inject it into the blood circulation of a healthy animal, the latter does not take the disease. In the same way, if cattle affected by East Coast Fever are placed among healthy cattle in a part of the country where none of these 'brown ticks' are found, the disease does not spread. It is evident, therefore, that some metamorphosis of the parasite must take place in the interior of the tick, and this new form of the parasite is introduced by the tick into a healthy animal, and so produces the disease. In this particular disease the virus or infective agent is not transmitted through the egg of the tick, as is the case in some of these parasitic diseases, but only in the intermediate stages of the tick's development; that is to say, the larva which emerges from the egg of the tick is incapable of giving the disease. What happens is this. The larva creeps on to an infected animal and sucks some of its blood. It then drops off, lies among the roots of the grass, and passes through its first moult. The nympha, which is the name given to the creature after its first moult, is capable of transferring the disease to a healthy animal: that is to say, if it crawls on to a healthy animal and sucks blood from it, it at the same time infects this healthy animal with the germ of E.C.F. In the same way, if a nympha sucks infected blood from a sick animal, it is able, after it has moulted into the adult stage or imago, again to give rise to the disease if placed, or if it crawls, upon a healthy animal.

The Life-history of the Brown Tick.—I throw on the screen a slide representing the four stages of the life-history of the brown tick: The egg, the larva, the nympha, and the adult or imago. The eggs are laid on the surface of the ground by the adult females, who deposit several thousands at a time; and these hatch out naturally, if the weather is warm and damp, in twenty-eight days. But this period of incubation of the eggs may vary very greatly owing to differences in temperature. Immediately after the larva is born it crawls to the summit of a blade of grass or grass stem, and there awaits the passage of some animal. If an ox passes by and grazes on the grass, the tick at once crawls on to the animal, and, having secured a favourable position, starts to suck the ox's blood. It remains on the ox for some three or more days, when, having filled itself with blood, it drops off and lies among the grass. The first moult, under favourable conditions, takes twenty-one days, when the nympha emerges. In the same way the nympha crawls on to an animal and fills itself with blood. As a nympha it also remains on the animal for about three or four days. It again drops off into the grass, and at the end of eighteen days emerges from its second moult as the perfect adult male or female. The males and females again crawl on to an ox, where they mate. After this the female tick ingests a large quantity of blood, which is meant for the nourishment of the eggs, and agains drops off, sometimes as early as the fourth day, into the surrounding grass. After about six days she lays her eggs in the ground, and the cycle begins again.

These ticks are very hardy, and in the intermediate stages can resist starvation for long periods, so that a larva or nympha or adult tick may remain perched at the end of a blade of grass for some months without finding an opportunity of transferring itself to a suitable animal. On this account it comes about that even if all infected cattle are removed from a field the ticks in that field will remain capable of transferring the infection to any healthy cattle which may be allowed into this field for a period of about a year. At the end of a year or fifteen months, however, the infective ticks are all dead, and clean cattle may be allowed into the field without any risk. If one takes these facts into consideration it will be seen that a single ox may spread this disease for a distance of some 200 miles, if trekking through the country at the average rate of ten miles a day. For

example, an ox is infected by a tick; for fourteen days the animal remains apparently perfectly well; it has no signs of disease, nor has it any fever. It is capable of doing its ten miles' trek a day. At the end of fourteen days the temperature begins to rise, and the animal begins to sicken with the disease, but for the next six days the ox is, as a rule, able to do its ordinary day's march. During most of this time the brown ticks have been crawling on to this ox, becoming infected, and dropping off every three or four days. It can readily, therefore, be seen how much mischief a single infected animal can do to a country between the time of its being infected by the tick and its death some twenty-four days later. As a matter of experience, however, the disease has never been found to make a jump in this way of more than fifty or sixty miles, as, of course, it is very rare that a transport carrier will take his oxen more than that distance during the twenty days.

At the present time it may be said that there are about 500 infected farms in the Transvaal. During last year some 15,000 cattle have died of the disease, and in the affected districts it may be said that there are still some 30,000 cattle alive. When one considers the value of the cattle dead of this disease, which may be said to be about 200,000*l.*, it is evident that money spent on the scientific investigation of the causes and prevention of stock diseases is money well spent. I am informed that all the South African Governments are cutting down their estimates this year, and are inclined to reduce their veterinary staffs and the amounts devoted to research regarding animal diseases. Ladies and gentlemen, if this is so, I have no hesitation in saying that this is the maddest sort of economy and the shortest-sighted of policies.

Methods of combating the Disease.—During the last three years an immense amount of work has been done in the elucidation of this disease—how the animals are infected, how the poison is spread from the sick to the healthy, and so on. In 1903 Professor Koch was asked by the South African Colonies to study this disease, in order to try to find some method of artificial inoculation or some other means of prevention. He did his work in Rhodesia, and especially directed his energies towards discovering some method of preventive inoculation. At first it was thought that he would be successful in this quest, as in his second report he announced that he had succeeded in producing a modified form of the disease by direct inoculation with the blood of sick and recovered animals. As you are all aware, the only method of conferring a useful immunity upon an animal is to make it pass through an attack of the disease itself, so modified as not to give rise to above a few deaths in every hundred inoculated. This is the method that has been employed in such diseases as Rinderpest, Anthrax, Pleuro-pneumonia, and many other diseases. The great difficulty in this disease in finding a method of preventive inoculation is the fact that the blood of an affected animal does not give rise to the disease in a healthy one when directly transferred under the skin of the latter. It is only after its passage through the body of the tick that the parasite is able to give rise to the disease in a healthy animal. It is evidently, on the face of it, difficult to so modify the parasite during its sojourn in the tick's body as to reduce its virulence to a sufficient degree.

Professor Koch in his third and fourth reports recommended that cattle should be immunised by weekly or fortnightly inoculations of blood from recovered animals, extending over a period of five months. Even though this method of Koch had given the desired result, viz. that it rendered the inoculated cattle immune to the disease, it is evident that the method itself can hardly be made a practicable one on a large scale in the field. The expense and trouble of inoculating cattle on twenty different occasions would be very great. It is apparent now that Professor Koch fell into error through mixing up East Coast Fever with ordinary Redwater. His plan of preventive inoculation was, however, tried on a large scale in Rhodesia by Mr. Gray, now the P.V.S., Transvaal, and found to be useless. At present, therefore, we must look to some other means of preventing the disease and driving it out of the country than preventive inoculation.

Dipping.—Much can be done to prevent the spread of this disease by ordinary methods. For example: in the case of Texas Fever in Queensland dipping cattle in solutions of arsenic or paraffin, in order to destroy the ticks, has met with very

fair success; but in the case of this disease we cannot expect to get as good results as in the case of Redwater. The species of tick which conveys Texas Fever remains on the same animal through all its moults, instead of falling to the ground after each different one. If it is not possible to spray or dip cattle oftener than once in ten or fifteen days, it is evident that ticks may crawl upon such animals, become infected, and drop off every three or four days, and so escape destruction by the dipping solution. At the same time every infected tick that is killed by spraying or dipping operations is a source of infection destroyed.

Fencing of Farms.—Again, the fencing of farms must also be useful in the same direction. As the ticks do not travel to any extent when they fall among the grass, it is evident that the cattle on a clean farm which is properly fenced will not become infected by this disease, although all the country round about should be infected. This fencing of farms and subdividing the farm itself into several portions is a most important factor in the prevention of contagious diseases amongst stock. It is, of course, impossible that this can be done at once, as the expense would be prohibitive.

Moving Cattle from Infected Pasture to Clean Pasture.—From a study of this disease and a study of the life-history of the tick it is evident that by a combination of dipping or spraying the cattle so as to destroy almost all the ticks, slaughtering the sick, and moving the apparently healthy on to clean veld—and repeating this, if necessary, a second or third time—it is obvious that by these means, if circumstances are favourable, an outbreak of this disease may be nipped in the bud without much loss to the stock.

Stamping out the Disease.—In May 1904, an inter-Colonial Conference held at Cape Town resolved that the only effective method of eradicating East Coast Fever is to kill off all the cattle in the infected areas, and to leave such areas free of cattle for some eighteen months. By this means all the centres of infection would be destroyed, and at the end of eighteen months, as all the infected ticks would be dead, it is evident that the disease would be completely stamped out. There is no doubt that this drastic method would be the quickest and most complete one of getting rid of this extremely harassing disease. If compensation were given, it could be done at a cost of, say, a quarter of a million. The Government decided, however, that on account of the difficulty of carrying out such a drastic scheme another policy had to be considered. This policy provides for the fencing-in of infected farms, places, lands, or roads, on generous terms; the compulsory slaughter of stock with compensation in the case of isolated outbreaks; the removal of all oxen from infected or suspected farms; and, lastly, the stabling of milch cows in infected areas. It is quite evident that under this less drastic policy the final stamping-out of the disease will be a much slower process than if the more drastic scheme of compulsory slaughter of all cattle on infected areas had been carried out. The benefits, however, from the modified scheme are undoubted; and if carried out thoroughly and intelligently for a period of several years will probably result in the stamping-out of the disease.

Allow me to sum up in regard to the advance in our knowledge of this important stock disease during the last ten years. Ten years ago nothing was known. Now the causation of the disease has been made out very fully; the parasite that causes it is known; the ticks which carry the infection are known. Although no method of conferring immunity on healthy cattle has been found out, or any medicinal treatment discovered which will cure the sick animal, yet our knowledge of the life-history of the parasite and the tick's enables regulations to be framed which, if patiently carried out, must be crowned with success.

2. *Redwater or Texas Fever.*

I may dismiss this disease in a few words. It is a most interesting disease and of great importance to stock farmers. It only affects cattle.

Geographical Distribution.—It is a disease found in almost every part of the world. It was first studied in North America; hence the name Texas Fever. To Kilborne and Smith is due the honour of elucidating the causation of this disease, and their work forms one of the most interesting chapters in the history of

pathological science. They discovered that it was caused by the presence in the red blood corpuscles of a protozoal parasite closely related to the parasite found in E.C.F.—the *Piroplasma parvum*. This organism is called *Piroplasma bigeminum*. They further discovered that this parasite was conveyed from sick to healthy cattle by means of a tick. They also showed that the cattle born and bred in certain southern districts are immune to the disease, whereas cattle in the northern districts are susceptible. Hence, if southern cattle were driven into the northern district, they gave rise to a fatal disease among the northern cattle; and, *vice versâ*, if the susceptible northern cattle were driven into the southern district among the apparently healthy cattle of that district, they took Texas Fever and died.

Texas Fever was introduced about 1870, and is now endemic throughout most of South Africa. For many years the native cattle have been immune to the disease; that is to say, on account of being born and bred in a Texas Fever locality they had inherited a degree of resistance to the disease which enabled them to pass through an attack when they were young, and so they became immune. But there is one peculiarity about Texas Fever which does not occur in Rhodesian Tick Fever, and that is that the blood of an animal which has recovered from Texas Fever remains infective—the germs remain latent—and so the native cattle of South Africa, although apparently healthy, are capable of infecting imported susceptible cattle with this very fatal malady. This is what makes it so difficult to import prize stock into this country.

When the Boers visited Mooi River, at the beginning of the war, they found a prize short-horn carefully stabled in Mr. P. D. Simmon's farm. They killed most of his stock for food, but left this short-horn bull alive. When they left the farm they turned this bull into the nearest field, in order, of course, that it might procure food. They had much better have eaten it. It promptly took Texas Fever and died.

This disease, then, has become of secondary importance to South Africa in these days. The native cattle have become naturally immune, and the disease is only fatal to susceptible imported cattle. This, of course, discourages the importation of prize stock; but with the knowledge we possess it ought to be possible, by good stabling and prevention of contact with tick-infected cattle, to keep the prize stock alive for a reasonable time. The question of the feasibility of immunising the prize stock while calves in England might be considered.

In regard to methods of conferring immunity on susceptible cattle many have been tried, but none are absolutely free from risk.

We may sum up in regard to Redwater or Texas Fever by saying that our knowledge of its causation and the methods of prevention are much the same as they were ten years ago. The work done by Smith and Kilborne on this disease was of such a brilliant nature, and was done so thoroughly, that little has been left for later workers to do.

3. *Biliary Fever of Horses, Mules, and Donkeys.*

This is a disease of horses, mules, and donkeys very similar to Redwater in cattle, and is caused by a closely allied parasite, the *Piroplasma equi*, discovered for the first time in South Africa by Bordet, Danysz, and Theiler, and named by Laveran of Paris.

It is similar to Redwater, in that animals which have recovered from the disease remain a source of infection during the remainder of their lives to susceptible animals. The native South African horse is, like the cattle, immune to the disease. It is also conveyed by a tick, which has been shown by Theiler to be the 'red tick' (*Rhipicephalus evertsi*), the infection being taken in the nymphal and transferred in the adult stage. Theiler has also made the very important observation that if a horse is injected with blood from a donkey which has recovered from the disease, as a rule a mild form of the disease is produced, so that this opens up a method of immunising susceptible horses which may probably prove of practical value. Theiler has also made another curious discovery. This disease of horses was found to greatly complicate certain immunising experiments he was making against Horse-sickness. He found he was introducing the *Piroplasma equi* at the same time he injected Horse-sickness virus.

But he found out that as the virus of Horse-sickness keeps its virulence for years, whilst the *Piroplasma equi* dies out in a short time, this danger could be avoided by keeping the Horse-sickness serum and virus for some time before using it.

4. *Malignant Jaundice of Dogs.*

This disease is most important to sportsmen or to importers of valuable dogs, as most of these are attacked sooner or later by this disease, and most of them succumb. It is also caused by a species of Piroplasma (*Piroplasma canis*), and is spread by the dog tick (*Hæmophysalis leachii*).

Like Redwater and Biliary Fever, the blood of dogs which have recovered remains infective.

The story of the tick infection is a curious one, and the credit of its discovery is due to Lounsbury. It is only in the adult stage that the tick is capable of producing the disease. It is therefore evident that the Piroplasma must remain latent in the egg, the larval and nymphal stages, and only attain activity in the adult stage.

According to Theiler there exists a peculiar phenomenon which may be made use of to confer immunity. The blood of a dog which has recovered from this disease and has been hyper-immunised is, as mentioned above, capable of giving rise to the disease in a susceptible dog. Now, if serum be obtained from this blood and a quantity added to a small amount of the blood, this infected blood loses its infectivity and no disease results.

II. Diseases caused by Parasites belonging to the Genus Trypanosome.

1. *Nagana or Tsetse-fly Disease.*

We now come to the second group of diseases. These are also caused by blood parasites belonging to the same class of living things as the Piroplasma, but which are free organisms, swimming in the fluid part of the blood, and not contained in the red blood corpuscles, as are the others.

The first of this group I would draw your attention to is that disease called *Nagana* or the *Tsetse-fly Disease.*

This fly renders thousands of square miles of Africa uninhabitable. No horses, cattle, or dogs can venture, even for a day, into the so-called 'Fly Country.' Now what was our knowledge of this disease ten years ago? At that time it was thought that the tsetse-fly killed animals by injecting a poison into them, in the same way as a snake kills its prey. Nothing was known as to the nature of this poison in 1894. In 1895, on account of serious losses among the native cattle in Zululand from this plague, the then Governor of Natal and Zululand, Sir Walter Hely-Hutchinson, started the investigation of this disease. The result of this investigation was the discovery that Tsetse-fly Disease was not caused by a simple poison elaborated by the fly, as formerly believed, but that the cause of the disease was a minute blood parasite which gained entrance to the blood of the animals. This parasite is known by the name Trypanosoma, which signifies a screw-like body.

Ten years ago two species only had attracted much attention—one living in the blood of healthy rats, discovered by Surgeon-Major Lewis in India; and the other, a trypanosome, found in the blood of horses and mules suffering from a disease known in India as 'Surra.' As the result of this investigation in Zululand, which lasted two years, it was proved that this trypanosome was undoubtedly the cause of the death of the horses and cattle struck by the fly, and that the tsetse-fly merely acted as a carrier of this blood parasite.

Here is a representation of the trypanosome of Nagana on the screen. These trypanosomes consist of a single cell; are sinuous, worm-like creatures, provided with a macronucleus and a micronucleus, a long terminal flagellum, and a narrow fin-like membrane continuous with the flagellum and running the whole length of the body. When alive they are extremely rapid in their movements, constantly dashing about, and lashing the red blood corpuscles into motion with their flagellum. They swim equally well with either extremity in front. These

organisms multiply in the blood by simple longitudinal division, and often become so numerous as to number several millions in every drop of blood. They are sucked, along with the blood, into the stomach of the fly, live and multiply in the alimentary tract for several days, and, when the fly has its next feed on an animal, take the opportunity of gaining access to the blood of the new host, and so set up the disease.

Let me now throw on the screen a representation of the tsetse-fly (*Glossina morsitans*) which does all the mischief. Experiments were made which showed that the fly could convey the parasite from affected to healthy animals for at least forty-eight hours. It is a curious fact that among all the blood-sucking flies the tsetse-fly alone has this power, and up to the present the cause of this has not been thoroughly cleared up. Lately, however, evidence has been brought forward to show that an enormous multiplication and development of the trypanosomes take place in the fly's intestine, a few trypanosomes multiplying to masses containing numberless parasites within twenty-four hours. Now, if this multiplication only takes place in the intestine of the tsetse-fly, and not in the other kinds of biting flies, this would probably account for the curious connection between the tsetse-fly and the disease. This multiplication of the trypanosomes in the tsetse-fly was discovered by Gray and Tulloch, two young Army medical officers, while working in Uganda on 'Sleeping Sickness' during the present year.

Not only was it found that the tsetse-flies could convey the disease from sick to healthy animals, but it was also proved that the wild tsetse-flies brought from the 'Fly Country' and straightway placed on healthy animals also gave rise to the disease. The question then arose as to where the tsetse-flies living in the 'Fly Country' came by the trypanosomes. There were no sick horses or cattle in the 'Fly Country.' Investigation brought to light the curious fact that most of the wild animals—the buffalo, the koodoo, the wildebeeste—carried the trypanosomes in small numbers in their blood, and it was from them that the fly obtained the parasite. The wild animals act as a reservoir of the disease. The trypanosome seems to live in the blood of the wild animals without doing them any harm, just as the rat trypanosome lives in the blood of healthy rats; but when introduced into the blood of such domestic animals as the horse, the dog, or ox it gives rise to a rapidly fatal disease. The discovery that the wild animals act as a reservoir of the disease accounted for the curious fact that Tsetse-fly Disease disappears from a tract of country as soon as the wild animals are killed off or driven away.

In 1895 the living trypanosome which causes the Tsetse-fly Disease was sent to England in the blood of living dogs, in order that it might be studied in the English laboratories. These trypanosomes have been kept alive ever since by passage from animal to animal, and have been sent all over Europe and America, so that our knowledge of this kind of blood parasite has rapidly grown.

Koch, in a recent address, says that our knowledge of protozoal diseases is based on three great discoveries—that of the malarial parasite, by Laveran; of the *Piroplasma bigeminum*, the cause of Texas Fever or Redwater in cattle, by Smith; and, lastly, this discovery of a trypanosome in Tsetse-fly Disease.

We may therefore, I think, congratulate ourselves on the growth of our knowledge of this great stock disease during the last ten years.

Since 1895 many other trypanosome diseases have been discovered in all parts of the world. The latest and most important of these is one which affects human beings, and is known as 'Sleeping Sickness.' This 'Sleeping Sickness,' which occurs on the West Coast of Africa, particularly in the basin of the Congo, has within the last few years spread eastward into Uganda, has already swept off some hundreds of thousands of victims, is spreading down the Nile, has spread all round the shores of Lake Victoria, and is still spreading southward round Lakes Albert and Albert Edward. This disease is in all respects similar to the Nagana or Tsetse-fly Disease of South Africa, except that it is caused by another species of trypanosome and carried from the sick to the healthy by means of another species of tsetse-fly—viz. the *Glossina palpalis*.

I now throw on the screen a map of Africa, showing, as far as is known up to the present, the various fly districts, and you will see from this map that it is not

at all improbable that this human Tsetse-fly Disease may spread southward through the various fly districts to the Zambesi, and may even penetrate as far as the fly districts of the Transvaal and Zululand.

I am sorry to say that, in spite of innumerable experiments directed towards the discovery of some method of vaccination or inoculation against these trypanosome diseases, nothing definite, up to the present time, has been discovered. At present there does not seem to be any likelihood that a serum can be prepared which will render animals immune to the Tsetse-fly Disease. In the same way it has also been found impossible, up to the present, to so modify the virulence of the trypanosome as to give rise to a modified, non-fatal form of the disease. Again, all attempts at discovering a medicine or drug which will have thepower of killing off the parasites within the animal organism, without at the same time killing the animal itself, have not as yet been successful, although some drugs, such as arsenic and certain aniline dyes (Ehrlich), have a very marked effect in prolonging the life of the animal. As this disease is fatal to almost every domestic animal it attacks, it seems very improbable that there is much chance of cultivating an immune race of horses, dogs, or cattle which will be able to withstand the action of the parasite. It is quite evident that if an acquired immunity of this kind could be brought about, such a race of immune animals would now be found; but, as a matter of fact, there are no horses, dogs, or cattle in the 'Fly Country.' In other protozoal diseases, such as the Piroplasmata, this acquired immunity seems to come about fairly readily.

To sum up, then, the increase in our knowledge of Tsetse-fly Disease during the last ten years, we may say that we have discovered the cause in the shape of the small blood parasite Trypanosoma; we have found that the reservoir of the disease exists in the wild animals, and that we can blot out this disease from any particular tract of country by the simple expedient of destroying or driving away the wild animals. We still have no means of preventive inoculation or successful medicinal treatment in this disease.

2. *Trypanosomiasis of Cattle.*

This disease seems to be widespread over all South Africa. It cannot be said to be of much practical importance, as the cattle infected do not seem to be seriously affected by it. It is caused by a species of trypanosome remarkable for its large size, which was discovered by Dr. Theiler some years ago, and named *T. theileri.*

Dr. Theiler states that it is conveyed from animal to animal by the common horse-fly, *Hippabosca rufipes.*

This, then, is a short account of the trypanosome diseases which affect South Africa.

Of late years the Tsetse-fly Disease has become of less practical importance to the Transvaal, from which it has practically disappeared. This is due to the disappearance of the game, killed off by Rinderpest; but with the preservation and restoration of the reserves with big game the disease is certain to reappear. Why the fly should disappear with the game is not known.

B. Parasite unknown.

I. *Rinderpest.*

We now turn our attention to the important diseases of the second group. In these the parasites causing them are unknown—that is to say, no parasites can be detected by the microscope or by culture—but it is equally true that they must be present in the blood and fluids of the sick animals in some form or other. In all probability they are ultra-microscopic—too small to be seen with our present instruments. This is borne out by the fact that they are able to pass through the pores of porcelain filters, which keep back the smallest micro-organisms we are able to recognise.

The first of the second group of diseases is Rinderpest, which has overrun and devastated South Africa within the last ten years.

Rinderpest has been known from time immemorial in Europe and Central Asia, and is an exceedingly fatal disease, killing 90 to 100 per cent. of the cattle attacked.

The recent epidemic, according to some, originated in the Nile provinces, and slowly crept southwards, reaching the Transvaal in 1896, after a journey lasting some fifteen years. Great efforts were made to oppose its passage, but nothing seemed to avail. In parts of the country where there were few or no cattle the epidemic spread by means of the wild animals—particularly the buffalo—which have been exterminated in many places.

Ten years ago the symptoms and contagious nature of this disease were well known, but nothing was known as to methods of prevention, and it is to the investigation of this epidemic in South Africa that the discovery of practical methods of immunising cattle, and in this way of stamping out the disease, is due.

As soon as it was apparent that the epidemic was spreading into South Africa, all the Colonies made strenuous efforts to combat it. The Transvaal Government invoked the aid of the Pasteur Institute, and Messrs. Bordet and Danysz were sent out to discover some method of prevention. They worked near Pretoria, and were assisted by Dr. Theiler, then the Principal Veterinary Surgeon. Before they arrived on the scene the Natal Government had despatched Mr. Watkins-Pitchford, their Principal Veterinary Surgeon, to the Transvaal, where he also at first had Dr. Theiler as his colleague, and where he did some good pioneer work in the serum therapeutics of the disease. In the Cape Colony Dr. Hutcheon, the Principal Veterinary Surgeon, and Dr. Edington, the Government bacteriologist, were no less active. It is, however, to Professor Robert Koch, of Berlin, that the honour is undoubtedly due of first publishing a practical method of immunising cattle against Rinderpest. He arrived at Kimberley on December 5, 1896, and in the incredibly short space of time of two months was able to report two methods of immunising, viz. by the injection of Rinderpest bile, and, secondly, by the injection of serum from immune animals. I have always thought that the discovery that the injection of bile taken from an animal dead of Rinderpest rendered cattle immune was particularly brilliant. Up to that time no one had dreamt that bile could possess such a quality. It is true that both Transvaal and Orange Free State Boers are said to have used a mixture of bile and blood from dead animals before Koch's researches, and also that Semmer in 1893 showed that serum might be used for protective purposes; but still to Koch is due the credit of making these processes practical. After he left South Africa his work was continued by Kolle and Turner, who greatly improved the methods; and it is to them, and to the other workers mentioned above, that we owe the fact that Rinderpest has now lost its terrors.

In the last recrudescence of this disease in the Transvaal, in 1904, Mr. Stewart Stockman, the Principal Veterinary Surgeon, and Dr. Theiler, thanks to the experience and knowledge gained during the last ten years, were enabled to stamp out the disease rapidly and completely. It is to them also that we owe our knowledge of the dangers of the intensive method of inoculation, much used in the past and due to Kolle and Turner, and the introduction of the fighting against the plague by the inoculation of the healthy cattle by injections of immune serum alone.

In the Tsetse-fly Disease our advance in knowledge has been in regard to the causation of the disease, and not in its prevention; it is quite otherwise with Rinderpest. The contagion or cause of Rinderpest is absolutely unknown. We know it exists in the blood, nasal, mucous, and other secretions of the sick animal, as all these are infective, but no one has seen it. The smallest quantity of blood will give the disease if injected under the skin of a healthy animal. We also know that the contagium is not very resistant. Blood soon loses its virulence after it leaves the body, and the effect of drying or the addition of chemical preservatives, such as glycerine, act also injuriously to the contagium, whatever it may be. It evidently belongs to the ultra-visible sort of micro-organisms, as it is said to pass through a porcelain filter.

How the contagium passes from the sick to the healthy is assumed to be by

contact. No experiments have, as far as I am aware, been made as to whether it is conveyed by insects as well; but, as Professor John MacFadyean says, as it spreads in all countries and climates and seasons, and the contagium is easily carried on the persons or clothes of human beings, it is improbable that insects have anything to do with it.

It is in the methods of protective inoculation that the great advance has been made in our knowledge of this disease. Ten years ago no means were available to stay the progress of this plague; now it has lost its terrors. As soon as it appears it can be immediately attacked and stamped out. This is done by rendering the surrounding cattle immune to the disease by injecting immune serum. This serum is prepared by taking immune cattle and hyper-immunising them by the injection of large quantities of virulent blood, so as to make their blood serum as anti-toxic as possible. If there are no immune cattle at hand, cattle can be immunised by Koch's bile injection method and then hyper-immunised; but, of course, in practice—for example, here in the Transvaal—large quantities of immune serum are kept ready for emergencies, and a herd of immune cattle kept up for the supply of the serum. This satisfactory state of affairs, as far as this disease is concerned, is, of course, the outcome of an immense amount of thought and experiment, and I have already mentioned the chief scientific men to whom this country owes this great boon.

Different methods of immunising have been tried during these years. Up to 1903 the prevailing custom was to use what was known as the virulent-blood and serum method. That is to say, immune serum and virulent blood were injected at the same time, in order that the animal might pass through a modified attack of the disease. Since 1903, however, in the Transvaal this method has been stopped, and the 'serum alone' method introduced. This method is based on the fact that the virus of Rinderpest does not retain its infective property outside the body for more than a day or two; that it dies out in the animal, as a rule, in fourteen days, but in chronic cases only after thirty days, and that therefore the healthy cattle in an affected herd must be protected for this length of time. Now 'serum alone' only protects for about ten days, and therefore the cattle must be inoculated three times at intervals of ten days. The doses of serum must also be large—from 50 cc. to 200 cc.—so that this method of stamping out Rinderpest, although quite efficacious, entails a good deal of labour. It is necessary, then, to spare no expense in making the Veterinary Department efficient, and any cheese-paring legislation in this direction may be disastrous.

II. *Horse-sickness.*

The next stock plague I would bring before your notice is Horse-sickness. This is a disease which only affects equines—the horse, mule, and rarely the donkey. It is a very fatal disease, carrying off thousands of horses every year. It is one of the most important diseases in South Africa, and, if it could be coped with, would enable the Transvaal to become one of the best horse-breeding countries in the world. At present it is dangerous for anyone in Natal and many parts of the Transvaal to possess a valuable horse, the chances of losing it by Horse-sickness being so great.

In 1895, when I went to the north of Zululand with the Ingwavuma Expedition, we lost all our horses with this disease. We started with a hundred horses, and had to march back on foot, every horse having died.

Ten years ago, when I arrived in South Africa, our knowledge of this disease was confined to the disease itself; nothing was known as to its causation or prevention. Credit is due to Dr. Edington for having accurately described the lesions and shown its ready inoculability, period of incubation, &c. He, however, fell into the mistake of attributing its causation to a species of mould fungus.

Etiology: Geographical Distribution.—Horse-sickness is widely distributed throughout Africa. It is common in Natal, Zululand, the greater part of the Transvaal, Rhodesia, Bechuanaland, and Portuguese East Africa. In Cape Colony

it occurs in epidemics, with intervals of ten to twenty years. It is undoubtedly a disease which prevails chiefly *in low-lying localities* and valleys, and is but rarely met with in elevated exposed positions. It, however, is met with now and then in river valleys up to an elevation of some thousands of feet. *Season* has also a remarkable influence on its development, being exceedingly common in summer and disappearing on the appearance of the first frosts of winter.

Ten years ago various theories were held as to the cause of this disease. Some people thought that it was due to eating poisonous herbs; others, to some peculiarity or state of the night atmosphere; others, to eating grass covered with dew; and still others, to the eating of the spiders' webs which may be seen on the grass in the morning. It was known at that time not to be contagious in the ordinary sense of that term; that is to say, a horse could be stabled alongside a case of Horse-sickness without incurring the disease, or a horse might be placed without danger in the same stall in which a horse had recently died of Horse-sickness.

Nature of the Disease.—A horse which has been exposed to infection shows no signs of the disease for about a week. Its temperature then goes up rapidly, and it dies after four or five days' illness. Very often the horse appears perfectly well until within a few hours of death. For example, my horse was the last one to die on the Ingwavuma Expedition. On the day of his death I rode him until noon without noticing anything amiss. He then became rather dull in his movements, and I handed him over to the groom to lead. He died that evening immediately after we got into camp. It is, therefore, a very rapidly fatal disease, and almost every horse which is attacked by it succumbs. I have never seen a case of Horse-sickness which had been brought on by artificial inoculation recover. But there can be no doubt that a small percentage of horses infected naturally do recover, and these recovered horses are, more or less, immune in future to the disease. There is no necessity for me to describe the symptoms of this well-known disease, as everyone who has to do with horses in South Africa is perfectly familiar with it, and everyone has seen dead horses with the characteristic mass of white foam issuing from their nostrils, due to the effusion of the liquid part of the blood into the lungs and trachea.

Nature of the Virus which causes this Disease.—There can be no doubt that this disease, like the Tsetse-fly Disease, is caused by some form of blood parasite. A small quantity of fluid taken from any part of a horse suffering from Horse-sickness is capable of giving rise to the disease if injected under the skin of a healthy horse. For example: the thousandth part of a drop of blood from a sick horse will, in many cases, give rise to the disease if injected under the skin of a healthy horse. It must be admitted, however, that some horses require a larger dose than others, but it may be said that no horse has yet been found to withstand more than a comparatively small quantity of infective blood thrown under the skin. Now, although every drop of blood must contain many of the organisms of this disease, yet the most careful examination of such blood under the highest powers of the microscope reveals nothing. Again, if we filter Horse-sickness blood through a porcelain filter—a filter which is capable of keeping back all the known visible micro-organisms—the filtrate is found to be virulent. It is evident, then, that we are here dealing with a blood parasite so small in size as to be absolutely invisible to the highest powers of the microscope, and also so minute as to readily pass through the pores of a Chamberland filter. What the nature of this parasite is one cannot tell. It behaves in many curious ways. For example, Horse-sickness blood which is simply dried and pounded into powder is found to be perfectly inert. On the other hand, blood kept in the moist condition remains virulent and capable of giving rise to the disease for years. Or, again, the germ of Horse-sickness is so resistant to external agencies that if, as described by MacFadyean, a part of the liver of a horse dead from Horse-sickness be buried in the ground and subjected to putrefaction, it is found that the liver tissue retains its infectivity for months. Although a very small quantity of blood introduced under the skin of a horse will almost certainly give rise to the disease, it is quite different if the blood is introduced into the stomach. In the latter case a

small quantity of blood has no effect, and the horse requires to be drenched with a pint or more before the disease can be given in this way.

The question now arises as to how horses are infected by this disease in Nature. On account of the small quantity of blood which will give rise to the disease if injected under the skin, and the large quantity required before the disease can be conveyed through the stomach, for a long time it has been supposed that it must be conveyed from sick to healthy horses by means of some biting insect. Experiments have been made within the last few years by Watkins-Pitchford and others in order to clear up this aspect of the question. Horses have been placed in fly-proof shelters in exceedingly unhealthy places, and it was found that in no case did any of these protected horses incur the disease; whereas horses allowed to feed in the same place, but without any shelter, soon succumbed to the disease. But, up to the present, as far as I am aware, the particular biting fly, mosquito, or other insect which is the carrier of this disease has not been discovered, and there can be no doubt that one of the most important facts to make out in the etiology of this disease is the discovery of the particular insect which conveys the disease from the sick to the healthy. By this discovery a flood of light may be thrown on the causation of the disease, and some means discovered of combating the disease through the insect, as has been successful in some instances in regard to the case of human malaria.

Professor MacFadyean also suggests that experiments are needed to show what is the 'reservoir' of the virus.

Prevention.—Although we have been unfortunate up the present in not being able to make out the exact nature of the parasitic cause of this disease, or to discover the exact insect which carries it, a large amount of patient persevering work has been done within the last ten years in regard to its prevention by protective inoculation.

In this important work Bordet, Edington, Koch, Theiler, Watkins-Pitchford, and others have laboured for many years, and, according to recent reports, with some measure of success.

Dr. Edington, for example, who has been working at this problem for several years, reports that Heart-water is identical with Horse-sickness, and that by inoculating mules with Heart-water blood he has been able to salt them against Horse-sickness. He says that experiments testing this vaccine show it to be an ideal one. It gives a high protection to the animals inoculated. Its keeping powers are excellent. No animal has died as the result of this inoculation, nor has any dangerous symptom been produced. He states that he is not in a position to supply a vaccine for Horse-sickness in horses, but has every hope of attaining this successful end very shortly.

We must congratulate Dr. Edington on his results, and trust that this method of conferring immunity may prove itself to be successful when put to practical use. For my part, I am somewhat sceptical of Dr. Edington's methods of immunising against Horse-sickness. I am sure he will forgive my expression of scepticism when I recall to his memory the various methods he has already brought forward, just as optimistically, and which have all been tried and found wanting.

Dr. Koch has lately recommended a method of immunisation against Horse-sickness. This is the artificial establishment of an active immunity in susceptible animals by gradually increased doses of virulent blood, alternated in the early stages of treatment with the injection of serum prepared from the blood of highly fortified salted horses. Mr. Gray reports that the experiments already conducted on these lines show that the process as laid down by Koch requires important modification before the process of establishing immunity against Horse-sickness can be of any practical use.

Mr. Watkins-Pitchford in Natal is also hopeful of succeeding in producing immunity against Horse-sickness.

Dr. Theiler, too, reports that he has succeeded in producing a serum which can be utilised in connection with virulent blood to confer active immunity. He informs me that his method is a subcutaneous injection of serum and an intra-jugular injection of virus carried out simultaneously. The death rate in mules,

from the effect of the inoculation, he states to be about 5 per cent. It is higher in horses, but he expects shortly to attain the same result in them. During the last Horse-sickness season he exposed 200 immunised mules to natural infection in various parts of the country. Of that number only one died with symptoms of Horse-sickness. As Dr. Theiler is himself communicating his method in detail to the Association, I need not enter more fully into it.

The man who discovers a practical method of dealing with Horse-sickness will be one of the greatest benefactors of this country. There has always been a tradition that a large money reward is awaiting this discovery. I do not know whether this is well founded or not, but certainly such a work would well deserve the highest possible reward. The best reward is to give the successful investigator more opportunity and more assistance in pursuing his beneficent work. The reward given by the French people to Pasteur was the Pasteur Institute; by the German Government to Koch, the Imperial Hygienic Institution.

Catarrhal Fever of Sheep: Blue Tongue.

This disease was first described by Hutcheon, the Chief Veterinary Surgeon of Cape Colony.[1] It is very similar in many respects to Horse-sickness. Both these diseases occur most often in low-lying, damp situations, such as river valleys and the coast plain. They also occur at the same time of the year; that is, from January to April. Blue Tongue, like Horse-sickness, is probably carried from the sick to the healthy by means of some night-feeding insect. At the same time the diseases are not identical, since the inoculation of Horse-sickness blood into a sheep does not give rise to Blue Tongue, nor the blood of the sheep injected into the horse give rise to Horse-sickness.

To Mr. Spreuill, Government Veterinary Surgeon in Cape Colony, acting under the advice of Hutcheon, is due the credit of proving that a preventive serum could be prepared capable of immunising sheep against this disease. Dr. Theiler informs me he has repeated Mr. Spreuill's experiments, and they hope to introduce this method of inoculation at an early date.

Heart-water of Cattle, Goats, and Sheep.

This disease was also first clearly described by Mr. Hutcheon. It occurs in the Transvaal, Natal, and Cape Colony, and is responsible for much of the yearly loss among the cattle, sheep, and goats.

Like the last disease—Blue Tongue—it resembles Horse-sickness in many ways, and, in fact, has been described by Dr. Edington as being identical with it. Like Horse-sickness, it is a blood disease with an invisible parasite, so that blood injected under the skin of susceptible animals gives rise to the disease. One difference between the parasites of the two diseases is, that whereas that of Horse-sickness is contained in the fluid of the blood, that of Heart-water is probably restricted to the red blood-corpuscles. The serum separated from the blood is incapable of giving rise to the disease, and the straw-coloured pericardial fluid, when injected into susceptible animals, fails to give rise to any symptoms of the disease. Horse-sickness blood filtered through a porcelain filter is still infective; the opposite holds good up to the present with Heart-water. Horse-sickness blood can be kept for years without losing its virulence; Heart-water blood loses it in forty-eight hours.

Heart-water has a peculiar distribution, being restricted to the certain tracts of country with a warm, moist climate. It is known to farmers that if they remove their flocks to the high veld the disease dies out.

To Lounsbury is due the credit of explaining these facts. He found that the disease is carried from sick to healthy animals by means of the bont tick,

[1] It is to Mr. Hutcheon that South Africa owes its knowledge of many stock diseases. For the last twenty-five years he has laboured with the utmost earnestness in Cape Colony, often under trying conditions, and his description of the various diseases formed the basis of all the modern work done on the subject.

Amblyomma hebræum. This tick leaves its host between each moulting, and a larva which sucks the blood of an infected animal is capable of giving rise to the disease in a susceptible animal either as a nympha or imago. The distribution of this tick corresponds to the distribution of the disease. If this tick could be killed off, the disease would disappear from the country. This could doubtless be done on individual farms by long-continued dipping; but in the meantime some method of immunisation might be devised.

CAPE TOWN.

WEDNESDAY, AUGUST 16.

Discussion on the Effect of Climate upon Health.

Sir Lauder Brunton said the effect of climate upon health was very ill-understood. It was in the same crude condition as the effect of drugs had been forty years ago. Any particular climate was the resultant of many factors, and was, as a rule, very incompletely analysed into its components.

Three primary points had to be considered with regard to any climate, namely, its action (1) on the human body; (2) on the organisms which give rise to disease; (3) on the carriers of disease.

The most general way of commencing an investigation of the subject would be a consideration of the effect of various climatic conditions upon protoplasm. For every cell there was an optimum temperature correlated with an optimum humidity; there was also an optimum degree of salinity for cells in a fluid medium. A series of determinations was necessary in order to obtain a definite guide as to the needs of the cells in the human body for water. The optimum of temperature for the body was 98°·4 F. When the temperature fell below that the force and rapidity of muscular contraction altered. The same diminution in vitality was to be seen in the metabolism generally. The amount of heat produced in the tissues was a very important factor in the temperature regulation of the body; this in its turn depended upon the degree of activity of the various organs. This point would be dealt with in greater detail by Mr. Barcroft at a later stage in the discussion. Over-exertion, however, predisposed to heat apoplexy, and complete inaction led to similar result. Climate, both in the matter of temperature and of moisture, was much affected by the nature of the soil. The soil also affected health by imparting its saline ingredients to the water, and the effects so produced on the patient were often mistaken for climatic effects. High winds intensified the general thermal conditions. Of the effect of electrical changes little was known. It was a matter of common knowledge that thunder was accompanied by headache, depression, and dulness in the case of many people. Weir-Mitchell had gone rather more definitely into the matter, and had found by a comparison of the reports from his patients with those of the meteorological authorities that a wave of pain passed over the American continent synchronously with a wave of electrical disturbance, as evidenced by rainstorms, traversing the United States. The rain areas were concentric with, but smaller than, the pain areas. Changes in barometric pressure had been studied by Dexter, who correlated a low pressure with crime, insanity, bad conduct, sickness, and suicide; with a high glass drunkenness was reduced and clerical errors were fewer.

Dr. Gregory dwelt on the lack of meteorological statistics which South Africa could provide in years past. In South Africa there were only two winds, easterly and westerly, each of which blew for half the year. It was noticeable that infectious diseases, as small-pox, typhoid, scarlatina, and influenza, occurred in a very mild form. Tuberculosis, however, was becoming a great scourge, causing a death-rate of 17 per 1,000 among the natives and 7 per 1,000 amongst the white population. It did not seem clear whether or not these facts were due to the climate.

Professor Bohr spoke specially of the effect of high altitude. He said that

most observers were agreed that about thirty millimetres was the lowest oxygen tension at which health could be maintained. Whilst this is the result of experience the result of his own experiments had been such as to provide a reason why this should be the case. The lung is covered everywhere with a film of moisture which has to take up the oxygen from the alveolar air. The first question is to consider at what rate oxygen can be taken up by this layer. This factor is quite irrespective of anything which may subsequently happen to the oxygen.

The amount of oxygen taken up per minute may be found out as follows:—

Let M be the quantity taken up; this may be considered as the difference between the quantity of oxygen passing into the surface and the quantity passing out of it. Let s be the surface of the lung, and p the partial pressure of oxygen in the alveolar air, whilst p_1 is concentration of the gas in the surface film, then $M = psi - p_1se$, where i and e are two constants known respectively as the invasion and evasion coefficients. Reference to the detailed exposition of the theory[1] shows that when the concentration of the gas in the fluid, as here, is expressed by the tension of the gas in the fluid (p_1) the constant e is numerically equal to i; we may replace them by the constant g.

$$M = sg(p - p_1).$$

The value of the constant g is experimentally determined to be 0·163; s, the surface of the lungs in square metres, is a known quantity; M is known to be 420 c.c. per minute.

If now p_1 be put at nothing, which is the minimum possible value, p, the lowest possible tension in the alveolar air, works out to be 29 mm.

Short of this limiting condition, the organism can compensate in various ways for a reduced oxygen tension, for instance, increased rapidity of circulation and increased quantity of hæmoglobin. Both of these phenomena are observed in the case of residents at high altitudes, and also during terms of strong muscular exercise.

Another way in which the oxygen tension in the blood may be raised, and so deficient respiration aided, is by an increase in the carbonic-acid tension. The carbonic acid reacts upon the hæmoglobin. Sometimes one of the above forms of compensation is used, sometimes another; hence the difference in the observed symptoms.

The most prominent signs of mountain sickness are bodily and mental apathy. These are due to decreased oxygen tension in the blood. This in turn may, in some cases, be accentuated by a deficiency of carbonic acid in the blood.[2] But another cause may be at work. Even without undue muscular activity, the heart, the muscles of respiration, and the cells all over the body, which are concerned in external and internal respiration, are being taxed under unfavourable circumstances, and therefore they become fatigued. The fatigue is sometimes most noticed after the object of it has left the rarefied air. Cases of this are quoted from the Thibet expedition.

An actual increase of metabolism does not seem to be a constant factor in mountain sickness.

Dr. J. A. Mitchell said that the secondary effects of climate were very important; for instance, much of the disease in South Africa might be attributed to the action of the high temperature upon stored foodstuffs.

Mr. J. Barcroft, on the regulation of heat in the body, said that of the two factors, heat production and heat loss, very little comparatively was known about the former. It was customary, especially amongst the French physiologists, to consider that the formation of heat took place almost entirely in the muscles. This was an erroneous view. The muscles contributed much to the heat of the body by reason of their great mass; but gramme per gramme of material, their calorific power was not nearly so high as that of such organs as the pancreas, the salivary glands, and the kidney, as the following data showed. In the last-named organ

[1] Nagel's *Text-book*, art. 'Respiration.'
[2] Mosso's *Alkapnœa.*

the amount of energy transformed in the secretion of water from the body was sufficient to raise the temperature of the water between 25° and 30° C. It thus happened that unless the water was cooler than the blood by something like this amount it did not really cool the body. Practically these results meant that in climates where the opportunities for loss of heat were not great (not damp climates) care should be taken not to throw over much work upon the glandular organs by excessive ingestion either of solids or fluids.

Professor SIMS WOODHEAD pointed out the necessity of meteorological definite data for the formulation of any true conceptions of the effect of the South African climate upon health.

THURSDAY, AUGUST 17.

Discussion on Stock Diseases in South Africa.

Mr. HUTCHEON, in opening the discussion, said that South Africa has obtained an evil reputation regarding the number and virulence of its stock diseases, of which only 'horse-sickness' was indigenous.

Pleuropneumonia came from Holland in 1854. More recently 'heart-water' appeared and spread over the Colony. It is not infectious, but is communicable to susceptible animals by inoculation. The late John Webb of Graham's Town associated this disease with the appearance of a new tick now known as *Amblyomma hebræum* (Koch). This observation was verified by Mr. Lounsbury, and is now generally recognised. The organism which infects the tick is hypothetical, but Mr. Robertson has shown that it does not pass through a Berkefeld filter. Artificial infestation with pathogenic ticks does not break down the immunity which he is able to confer by successive inoculations so readily as does intravenous injection of virulent blood (dose 5–10 c.c.).

The next animal plague that invaded South Africa was 'redwater,' 'Texas fever,' or *Piroplasma bovis*. It came to Natal in 1870, probably from the East Coast. It is now endemic throughout Natal, much of the Transvaal, Rhodesia, and Cape Colony. It is now combated with considerable success by inoculation. The inoculation takes place in the winter and spring months, with blood from an infected animal, *Rhipicephalus decoloratus*. The tick which transmits redwater was discovered by Dr. Theobald Smith in 1889.

Rinderpest appeared opposite Aden in 1889, at Bulawayo in March 1896, it crossed the Vaal in March 1897, and was checked most successfully by a large dose of standardised serum. Coast fever was first discovered in German East Africa by Dr. Koch in 1897. It was looked upon as a virulent form of redwater. This is not the case, but frequently occurs as a complication. The organism of East Coast fever has been described by Dr. Theiler, P.V.S. of the Transvaal, and called by him *Piroplasma parvum*. Among other important differences between the two diseases this one stands out—namely, that while the blood of cattle immune to redwater is still infective, the blood of animals immune to African coast fever is not infective, not even to ticks.

Having considered biliary fever, *Piroplasma equi* and *Piroplasma canis* in detail, Dr. Hutcheon passed to horse-sickness. The first horses were imported in 1652, and they increased rapidly till 1719, when horse-sickness appeared. It reappeared in 1763 and carried off 2,500 horses. From time to time it passes like a wave over the Colony; in 1854 and 1855 70,000 horses died of it, and a like number in 1891 and 1892. Dr. Hutcheon attributed the absence of horses in South Africa to this disease, which he regarded as being perpetuated.

Mr. CHAS. P. LOUNSBURY then communicated the chief conclusions drawn from numerous experiments conducted for the Cape Government during the last five years by the writer with the object of elucidating the asociation of ticks with certain animal diseases. Introductory notes treated of the main features in the economy of ticks. Heart-water, a febrile disease of cattle, sheep, and goats, which prevents the successful farming of woolled sheep and angora goats in an extensive

tract of country, has been found to be associated with *Amblyomma hebræum.* The tick becomes infected with the undiscovered organism of the disease in one stage of its life-cycle, and communicates it at a later stage. To some extent infection is dependent on temperature, since the tick fails to convey the disease if it has not been subjected to a requisite degree of warmth during or subsequent to the transition from one stage to the other. Infection may be transmitted from one kind of the animal subject to it to any of the other kinds. Sheep of the Persian breed take the disease mildly, but the virulence of the infection does not appear to be modified by passing through them. The incubation period averages several days longer when the infecting ticks are applied to the leg than when applied to the abdomen; but the transmission of the infection is supposed to take place within twenty-four hours after the ticks attach. Infection has resulted through the bite of a single tick. Animals which recover soon lose the capacity to infect ticks, but it appears that their immunity is only relative, and it is therefore suspected that they may be a medium of continuing the infection. The progeny of the transmitting tick appears innocuous. Canine piroplasmosis has been found associated with *Hæmaphysalis leachi.* The infection may be derived from sick or recovered animals. It appears to be transmitted only by adult ticks which are the progeny of females off infective animals. In other words, the infection passes through the egg stage of the tick and remains latent during the larval and nymphal feedings. Most of the experiments in connection with bovine piroplasmosis have failed to afford conclusive results for reasons not yet fathomed. The only perfectly satisfactory case induced under observation by ticks was one due to larval progeny of *Boophilus australis* females off a recently recovered animal. *B. decoloratus* is presumed to be the common transmitter of the disease. African coast fever has been found to be communicated by ticks in a manner analogous to heart-water, that is, by nymphs or adults which in the previous stage fed on a sick animal. Five species of the sub-genus *Eurhipicephalus, appendiculatus, nitens* (?), *evertsi, simus,* and *capensis*, have been found implicated. No infection has been derived from recovered animals, and none has resulted from the application of the progeny of females of any species of tick off sick animals. The duration of the fever period averaged twelve and a half days in the cases produced; so there appears an abundance of time for larvæ and nymphs of the various species of *Eurhipicephalus* to become infected.

Colonel Bruce thanked Mr. Lounsbury and Dr. Hutcheon for their papers; the latter had laid the foundation of all their knowledge of South African stock diseases, and Mr. Lounsbury's work on ticks was of the most brilliant character. The value of such work could not be over-estimated by those in authority or by the owners of stock, for horse-sickness had killed 78,000 horses in a single year.

Sir Walter Hely Hutchinson also expressed his thanks to Mr. Hutcheon and Mr. Lounsbury for their papers. He believed that the farmers were becoming alive to the importance of ticks as carriers of disease; they had, however, to combat enormous difficulties, notably, that bucks, hares, &c., were infested by this tick, as well as cattle, and therefore it was almost impossible for the farmers to clean their farms.

Mr. Robertson said that osteoporosis in equines was first recognised in 1880 by Professor Varnel. It made its appearance at Port Elizabeth among race-horses; and as most of those affected were progenies of the same sire, it was supposed to be due to hereditary predisposition. Serious outbreaks occurred at Wynberg amongst the Argentine horses during the recent war, and also at Kimberley, Johannesburg, and elsewhere. The disease was spreading so fast that it bid fair to become one of the scourges of South Africa; nor was it confined to any particular breed of horse.

The disease had been compared to osteo-malacia, but in his opinion was absolutely distinct from it. It was in no way due to insufficient phosphates in the food, and was in his belief an infectious disease, and he was not without hope of introducing remedial measures by inoculation.

FRIDAY, AUGUST 18.

The following Papers were read:—

1. *So-called Scurvy of South Africa.* *By* Dr. A. J. Gregory.

Dr. Gregory said that he proposed to deal with the disease under the following heads: (1) Its incidence, extent, and distribution; (2) its clinical characters and the effect of treatment; (3) the influence of diet; (4) seasonal variation; (5) probable infectiveness. Having dealt with the disease from these standpoints, he said: To summarise I may recapitulate my conclusions regarding this disease. They are: (1) In its clinical features it closely resembles mild scurvy, but may result in a considerable mortality; (2) it occurs in communities supplied with a sufficient fresh meat and vegetable dietary, and it does not necessarily occur in communities living on a dietary almost entirely deficient in these constituents; (3) the employment of fresh vegetables and vegetable juices does not afford a specific cure for the disease. Cases may continue for long periods, although under a liberal anti-scorbutic diet; (4) the disease is characterised by a very high percentage of recurrences; (5) its incidence is greatest on the native races; (6) it occurs in the form of outbreaks and epidemics; (7) different outbreaks vary in intensity or virulence of type, indicated by a larger proportion of attacks and a greater fatality; (8) the disease is marked by a distinct seasonal variation; (9) it is essentially a disease of aggregation or close association; (10) there are indications that the disease may be of bacterial origin and mildly infectious in its nature; (11) there are grounds for believing that a disease not entirely in accord with the accepted ideas of scurvy occurs in other parts of the world besides South Africa. With this I must leave the matter for further investigation, in the hope that it will be taken up by other and more able investigators than myself. Whether my views be right or wrong, I still think that the facts I have stated are sufficient to warrant further inquiry being made into the nature of scurvy—at any rate as we meet with it in this part of the globe.

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2. *Plague in Cape Colony.* *By* Dr. J. A. Mitchell.

Dr. Mitchell approached the subject from the point of view of the practical sanitarian. He detailed the history of the introduction of the disease into the Colony in 1899 and its subsequent spread. Up to the present epidemics of the disease have occurred at Izeli (King William's Town district), Cape peninsula, Port Elizabeth, Mossel Bay, East London, King William's Town, Queenstown, Kei Road, and Knysna; whilst plague epizootics amongst rodents have occurred in Graaff-Reinet, Uitenhage, Burghersdorp, Seymour, Thomas River, Lady Grey Bridge, and Grahamstown. Port Elizabeth, East London, King William's Town, and Uitenhage are still plague-infected. There have been 1,305 cases, with 665 deaths, equal to a case mortality rate of 50·8 per cent. All the epidemics, with the exception of that at Izeli, where there were no rodents, were associated with epizootics of the disease amongst rodents. The disease has been observed in veld rats (*Arvicanthus pumilio*), cats, and in one dog. After tracing the connection between infected rodents and the occurrence of cases of the disease in man, and the mode of spread from infected centres to other centres in the Colony, Dr. Mitchell said that, from the history of the disease in the Colony, the following conclusions might be drawn: (1) That rats have, directly or indirectly, been the means of introducing the disease into the ports of the Colony; (2) that rats have, directly or indirectly, been the means of spreading the infection from infected centres in the Colony to other centres; (3) that in the majority of cases of the disease in man the infection has been more or less clearly traceable to infected rats; (4) that rats have been the chief cause of the persistence of the disease in the infected localities. He also dwelt on the great danger of the introduction of plague by infected rodents into countries hitherto free from the disease, and

characterised as a vital defect the omission in the International Health Convention of Paris, 1903, of provision for the inter-State notification of the occurrence of plague amongst rodents, except when associated with cases of the disease in man.

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3. *Leprosy in South Africa. By* Dr. S. Black.

JOHANNESBURG.

TUESDAY, AUGUST 29.

The President delivered his Address (see p. 533), after which the following Papers were read:—

1. *Rinderpest: its Prevention and Cure. By* Hon. George Turner.

Rinderpest first appeared south of the Zambesi in 1896. It was probably transmitted from the Soudan. In England, in 1865, destruction of infected herds alone produced any good effect. The disease was imported into Hull in May 1865, and was recognised in the metropolis in the following July. By December 30 9,753 farms were infected. An order to destroy was made on May 9, 1866, and by the following November the disease was stamped out. Slaughtering in Cape Colony was recommended by Mr. Hutcheon, and his opinion was supported by Professor Flemming. It undoubtedly was productive of good, inasmuch as it temporarily arrested the disease and afforded time for Professor Koch to introduce the bile method of immunisation (February 1899).

The signs and symptoms of rinderpest were briefly sketched.

Dr. Koch and others failed to demonstrate the specific organism. The claim of Messrs. M. Nencke, N. Sieber, and Wyznikiewiez to have done so was discussed. The organism, however, must be of sufficient size to be visible under the powers usually used in such investigations, and is probably intracorpuscular. The various excretions, also the hides of animals dead of the disease, soon lose their infectivity.

Professor Koch's bile method was described, and its utility demonstrated, its defects and limitations being discussed. The theory that bile inoculation can spread the disease was considered, and reasons for supposing that it is not well founded given.

The glycerinated bile method was described and condemned.

The method used to produce a powerful serum capable of immunising cattle and curing the disease in the early stage was detailed, also the Kimberley process, *i.e.*, the simultaneous inoculation of virulent blood and immunising serum. The results obtained may be summarised as follows:—

Amongst infected herds there were 3,318 animals: 1,077 were known to be sick of the disease. Serum was used; 2,857 recovered—a saving of 86·1 per cent.

The simultaneous method was employed on 10,407 animals. The resulting loss was 136, or 1·3 per cent.

The nature of the substance contained in the serum was discussed. *In vitro* it has little power. *In corpore,* provided that the serum bears a certain proportion to the body-weight, the amount of blood injected to produce the necessary specific fever is of no consequence; 2,000 c.c. do not produce a greater effect than 0·2 c.c. of virulent blood. The method of inoculation used probably resulted in a saving of 986,518 animals. Four thousand four hundred and seventy-two litres of serum were issued from the Kimberley Rinderpest Station, sufficient to immune 203,600 animals; the serum sold readily at 7*l.* 10*s.* per litre.

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2. *The Advance of our Knowledge respecting the Stock Diseases of South Africa.* *By* Dr. A. Theiler.

1. Diseases caused by ultra visible micro-organisms :—

(*a*) Horse-sickness and malarial catarrhal fever may be considered together: both occur under similar telluric and climatic conditions, but the former is more especially prevalent in low-lying parts, while the latter is found on higher levels where, in epizootic years, the horse-sickness may also appear. Both diseases occur during heavy rains, especially during the latter half of the rainy season. Animals are infected during the night. They cease as soon as frost comes. Both are inoculable in animals of the same species, but are not contagious. The two diseases, horse-sickness and Blaauw tongue or catarrhal fever, are distinct. The virus is easily destroyed by desiccation, but is not affected by cold. Both are conveyed from animal to animal by nocturnal insects. Veterinary Surgeon Spreuill, of the Cape Colonial Service, by hyper-immunising sheep with virulent blood has succeeded in producing a serum efficacious in cases of Blaauw tongue. The author has succeeded in immunising mules against horse-sickness by the simultaneous subcutaneous injection of serum and intravenous injection of virus. The resulting death-rate is 5 per cent. It is higher in horses.

(*b*) Heart-water in sheep and other domestic ruminants.—This disease is inoculable from sick oxen to susceptible oxen, sheep, and goats. The organism is attached to the red blood-corpuscles: it cannot be cultivated, and does not pass the Berkefeld filter. Blood loses its virulence in forty-eight hours. Heart-water is not contagious. Mr. Lounsbury, of the Cape Service, found that it was propagated by the *Amblyomma hebræum*, commonly known as the tortoise tick. Certain varieties of sheep suffer less than others; for instance, Persian sheep may sicken, but do not die. The tick may be eradicated by repeated dippings over a protracted period, but at present this is not practicable in the Transvaal. Animals hyper-immunised produce a powerful serum.

2. Diseases caused by protozoa :—

(*a*) Diseases caused by Piroplasmata.
(*b*) Diseases caused by Trypanosomes.
(*c*) Diseases caused by Spirilla.

(*a*) There are two varieties of Piroplasma: of one, the *Piroplasma bigeminum* of Texas fever may be considered as the type, and the *Piroplasma parvum* of Rhodesian fever as the type of the second. To the first type belong the *Piroplasma equi* and the *Piroplasma canis*. The diseases caused by these parasites are characterised by anæmia, jaundice, hæmoglobinuria, and an enlarged spleen. All three are inoculable and recovery results in a certain amount of immunity. They are all spread by ticks—Redwater by the *Rhipicephalus decoloratus* and the *Rhipicephalus annulatus*; equine Piroplasmosis, or biliary fever of horses, is spread by the red tick, *Rhipicephalus evertsi*; biliary fever, or malignant jaundice of dogs, is conveyed through the dog tick, *Hæmophysalis leachi*. There is only one disease caused by organisms of the second type, *Pirosoma parvum*, and that is Rhodesian fever. It is not conveyed by inoculating a susceptible animal with the blood of one suffering from the disease. It is communicated by two ticks, the *Rhipicephalus appendiculatus* and *Rhipicephalus simus*. The infection does not pass through the egg, and an infected tick having once bitten cannot again cause the disease. The blood of the immunised ox does not contain the parasite in any shape; consequently after a farm has been cleared of cattle for fourteen months it can again be stocked with safety.

(*b*) Diseases caused by Trypanosoma: (i) Nagana, or tsetse-fly disease; (ii) Specific trypanosomasis of cattle.

Nagana only exists in a few places in Zululand and Rhodesia. Dogs and horses are very susceptible, but sheep and goats have a prolonged disease, and the ox may survive for years. The disease is conveyed by the fly *Glorsina morsitans*. Specific trypanosomasis of cattle occurs all over South Africa. Infected cattle

rarely die. The parasite is the largest known. It is carried by *Hippobosca rufipes.*

(c) Disease caused by a spirillum.—A spirillum causing anæmia is found in the blood of oxen, especially in poor animals. It is inoculable from the ox to the ox and to sheep. The parasite is found in the blood of immune animals; it is caused by the blue tick passing through the egg, and is inoculable by the larva.

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3. *On the Nature of the Silver Reaction in Animal and Vegetable Tissues. By* Professor A. B. MACALLUM, *Ph.D.*

When fresh preparations of animal and vegetable tissues are treated with a solution of nitrate of silver containing free nitric acid, and then exposed to light, they become coloured, the colour varying from reddish to violet. The author endeavoured to determine to what the reaction is due. It was found that of the organic constituents of tissues the only ones to form compounds of silver which reduced under the influence of light were sulphocyanic acid, creatin, and taurin. As creatin is present only in vertebrate muscle-fibre, and not at all in the tissues of invertebrates, while the other compounds mentioned occur in tissues only in infinitesimal, and, therefore, in negligible quantities, the silver reaction cannot be attributed to their presence. It was further ascertained that neither phosphates, carbonates, nor sulphates give coloured silver compounds in the presence of free nitric acid. There remained, among organic compounds in tissues, only the proteids, and as these are generally held to form, with silver salts, compounds 'reducible' under the action of light, it was necessary to determine whether the coloured compounds so formed are 'albuminates' or simply subchoride of silver. For this purpose proteids were freed from chlorides by repeated precipitation with pure ammonium sulphate, and it was found that egg and serum, albumins and globulins, as well as gelatins, after the eighth precipitation, give no reaction whatever with nitrate of silver under the influence of light, and that the compounds eliminated by the precipitation, and to which the silver reaction is due, are chlorides. Nucleoproteids also were found to be reactionless. In the case of vegetable proteids the method employed was different, but the result was the same. Silver nitrate in the presence of nitric acid may, consequently, be used as a micro-chemical reagent for determining the presence of chlorides in animal and vegetable tissues, and its use for this purpose has already given some very important results. This reaction, together with that used by the author to demonstrate the occurrence of potassium, renders it possible to determine not only the presence or absence of haloids, but also, not infrequently, of sodium.

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4. *On the Distribution of Chlorides in Animal and Vegetable Cells. By* Professor A. B. MACALLUM, *Ph.D.*

The employment of solutions of nitrate of silver containing free nitric acid on fresh tissues, animal or vegetable, followed by exposure of the preparations to sunlight, constitutes a valuable method for determining the distribution of chlorides in animal and vegetable cells, and it has been used by the author for this purpose. Among the results which have been thus obtained are the following:—

1. The cell nucleus is, when normal, absolutely free from chlorides.
2. Chlorides are absent from the head of the spermatozoon (frog, rat, and guinea-pig).
3. The cytoplasm of nerve cells gives an almost uniform reaction for chlorides.
4. Inert protoplasmic structures, as well as intercellular material, *e.g.*, the so-called cement substance of Von Recklinghausen, are rich in chlorides.
5. Chlorides are abundant in the parietal cells of the gastric glands, less abundant in the chief cells (guinea-pig), and they are more abundant in the granular than in the protoplasmic zone of the pancreatic cells (guinea-pig).

6. Chlorides are absent from chlorophyll corpuscles (*Tulipa* and *Iris*), and from the chromatophore of *Spirogyra* and *Zygnema*.

7. In *Spirogyra* and *Zygnema* the chlorides are confined almost wholly to the peripheral protoplasmic membrane, or layer, lining the cell-wall. Very frequently a like distribution is found in the chlorophyll-holding cells of the higher forms (*Iris, Tulipa*).

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5. *Some Points in the Micro-chemistry of the Nerve Fibre.* *By* Professor A. B. MACALLUM, *Ph.D., and* Miss M. L. MENTEN, *B.A.*

The silver reaction of tissues in the presence of free nitric acid having been shown by the senior author to be due to the formation of chloride of silver and the reduction of this in sunlight to the dark subchloride, it was used to determine the occurrence and mode of distribution of chlorides in the nerve fibres. The use of nitrate of silver, as is well known, serves to show the occurrence of the nodes on the fibre, and the reaction obtained extends some distance on either side of the node, usually in the shape of rings, known as those of Frommann. This reaction the authors now find is due to chlorides, which seem to diffuse towards the nodes to meet the reagent diffusing into the fibre. The result is a series of deposits in the shape of bands or zones; but this disposition of the precipitate is wholly due to physical causes, as it may be obtained also in capillary tubes filled with egg albumin or gelatin and placed in a solution of nitrate of silver. In other words, the deposits of the subchloride of silver are in bands or zones, while in the intact fibre the chlorides are uniformly distributed throughout the length of the axon. Where the reagent gets a free entrance to the axon, as may obtain in specially made preparations of the spinal cord, the reaction may be quite uniform along the axon and without an interruption. That the reaction is due to chloride may also be shown by using mercurous nitrate, which gives a precipitate of mercurous chloride, and this, after removal of the precipitant, may be revealed by the addition of ammonium sulphide. The result of the employment of this reagent is to show exactly the same distribution as revealed with nitrate of silver.

The conductivity of the axon for nerve impulses is undoubtedly dependent on the presence of chloride of sodium, not free between the molecular aggregates of the colloid, but enclosed in them, the superficial layer of each of which, acting as a semi-permeable membrane, diminishes the velocity of the charge-bearing ions.

WEDNESDAY, AUGUST 30.

The following Papers were read:—

1. *The Life-history of the Coloured Labourer in the Transvaal. By* LOUIS G. IRVINE, *M.A., M.D., B.Sc., and* DONALD MACAULAY, *M.A., M.B., C.M.*

This paper dealt with only one aspect of the larger native-labour question, namely, the description of the conditions under which the native labourer lives and works, and was meant to form an introduction to the actual inspection of these conditions by the members of the Association at their visit to a 'compound' hospital.

The author therefore described where the native labourer comes from, how he gets to the Rand, what his work consists in, how he is treated, and how he fares.

The following were the main points discussed:—

1. Sources of the native-labour supply. Contributions of the various territorial areas.

2. Methods of recruiting by the Native Labour Association. Regulation of recruiting.

3. How the native is brought to the Rand. The detention compound at Johannesburg.

4. Work and life on the mines. Classes of work in which the native is engaged. Housing. Food. Sanitation. Hospital accommodation. General conditions of living. Average stay on the mines. General character of the natives. General treatment.

5. Sickness and mortality. Excessive mortality in the past. Means taken to combat it. What the mines have done. Improvement effected. The still relatively high mortality. Main diseases contributing to it. Importance of the territorial factor, climate and racial. Importance of the factor of occupation. Other factors. The problem of acclimatisation.

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2. *Diseases among Natives.* *By* Dr. G. LIENGME.

The data are for the most part collected from the hospital of the Swiss Medical Mission, Spelonten, N. Transvaal.

Of native children 30 per cent. die before they reach the age of two years.

Diseases of nervous system occur as follows:—

1. Hysteria is exceedingly common, often succeeded by a hypnotic condition. The author has operated for a tumour on a patient in a hypnotic condition.
2. Epilepsy is common, and occurs at a more advanced age than is usual among whites.

Diseases of the organs of respiration:—

1. Pneumonia and bronchio-pneumonia. At certain seasons this is very prevalent, and great infant mortality arises in consequence. Malaria predisposes to it.
2. Pleurisy and asthma are infrequent.
3. Pulmonary tuberculosis was unknown a few years ago; now it is common. It runs a more rapid course than among whites. The bacillus is frequently imported by young men from the mines.
4. Diseases of the heart are infrequent.
5. Diseases of the kidney are infrequent.
6. Hæmaturia due to bilharzia is common.
7. Diseases of digestion are uncommon except in young children.
8. Conjunctivitis, often leading to blindness, is very common.
9. Leprosy in a mild form is very common. The first stages usually pass unnoticed. The native usually carefully hides the disease, fearing transportation to a leper asylum.
10. Cases of difficult labour are more frequent than might be supposed.
11. Malaria is the cause of much suffering.
12. Syphilis first appeared thirty or forty years ago: it came from the mining centres. Now 80 per cent. of the whole native population of Zoutpansberg are infected. It can be treated successfully with mercury, which, however, must be given in smaller doses than to whites.

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3. *Drugs as used in South Africa.* *By* Dr. MABERLEY.

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4. *The Action of Radium on the Electric Phenomena of the Retina.* *By* Professor J. G. McKENDRICK, *F.R.S.*

FRIDAY, SEPTEMBER 1.

The following Papers and Reports were read:—

1. *The Administration of Chloroform.* *By* AUGUSTUS D. WALLER, *M.D., LL.D., F.R.S.*

The author said: The subject on which I would like to invite your consideration and criticism to-day concerns the value of acquiring a physiological and arithmetical conception and understanding of the conditions of safe anæsthesia.

Picture the lungs with a surface of 100 square metres, a blood surface of 75 square metres containing a total volume of air of 5 litres, and a tidal air at each inspiration of half a litre, or 500 c.c.

Successful chloroform anæsthesia requires the regular respiration of air in which chloroform is maintained between the limits of 1 and 2 per 100. In my experiments in the laboratory on isolated frog's nerve 5 per cent. vapour is found to be the outside limit of safety, and is fatal if persisted in; and it so happens that Snow fifty years ago named 5 per cent. as the limit beyond which one dared not go in anæsthesia of the human subject. Snow, in 1850–55, and Paul Bert, in 1880–83, did their best to place the administration of chloroform upon a rational basis. But, partly by reason of the difficulty of getting out chloroform percentages and partly by reason of the facility with which chloroform can be administered without any reference to percentages at all, the teaching of Snow and Bert did not produce its full effect upon clinical practice, and fatal accidents continued to take place—fatal accidents that could not have taken place if the principles of Snow and Bert had been properly appreciated.

I regard as a substantial contribution towards safe anæsthesia, not the publication of fragmentary 'statistics,' nor the advertisement of 'safe' instruments, but the acquisition of a simple method by which we can rapidly ascertain the percentage of chloroform offered to inspiration by any means. And of the study in which I have been engaged during the last ten years I should attach greatest importance to the realisation of the simple fact that a quarter litre of air and chloroform weighing one to two centigrammes more than a quarter litre of air alone contains 1 or 2 per cent. of chloroform vapour, since by this means we can easily test the percentage in any method of administration. This method of densimetry was introduced by myself and Dr. Geets in 1902. The principle upon which the method is based is as follows:—

1,000 c.c. of $CHCl_3$ vapour	weighs	5,325 mg.
" " atmospheric air	"	1,293 mg.
Difference	=	4,032 mg.

i.e., 1,000 c.c. $CHCl_3$ replacing 1,000 c.c. air gives an increment of weight of 4,032 mg. 1 c.c. $CHCl_3$ vapour replacing 1 c.c. air gives an increment of weight of 4 mg., or, that is, 2·5 c.c. of $CHCl_3$ vapour; 2·5 c·c. of air gives an increment of weight of 10 mg., so that with a 250 c.c. bulb each 25 c.c. of $CHCl_3$ vapour, that is, each 1 per cent., is represented by an increment of weight of 10 mg.

Corrections for temperature and pressure and volume may be made, if thought desirable, from the formula $\log P = 1{\cdot}8377 + \log M - \log N + \log T - \log B$, where P is percentage, M increment of weight in milligrammes, V capacity of densimeter in cubic centimetres, T absolute temperature, B barometric pressure and 1 8377.

At Johannesburg B is 600 mm.

Two glass densimeter bulbs are weighed against each other and the weights adjusted to balance them: one of them is then filled with the vapour to be estimated and weighed again, and the difference in weight indicates the percentage. The bulb is inserted in the delivery or aspirating tube and protected by indiarubber bags, so that it can be stoppered and unstoppered without entrance of atmospheric air. The vapour supplied from a skinner's mask has been tested in this way, drawn by aspiration from beneath the mask.

In practice, as recommended by the Scotch school of anæsthetists, 'plenty of

chloroform with plenty of air,' the percentage is found to be from 1 to 2 per cent., and the large amount of chloroform used and the free admixture with air produces a more nearly uniform supply to the patient's lungs than when small quantities and a closer method, with its alterations of 'off' and 'on,' are resorted to; and by means of densimeter determinations have shown that the ordinary percentage of mixture supplied by this rough method lies between the desired limits of 1 and 2 per cent. The great danger of this method is that, should the fabric be crammed down over the patient's face, the percentage may rise to five times or more the upper limit of safety.

Of the different types of apparatus obtainable preference should certainly be given to those worked on the principle of supplying the anæsthetic mixture freely by propulsion to an open and loosely fitting face-piece rather than to those which are set in action by the inspiratory movements of the patient himself, because of the fact that if the respiration become weaker the vapour in the apparatus not being drawn over quickly enough becomes more strongly saturated, and a dangerous percentage may be suddenly reached.

Given the requisite care and skill and knowledge on the part of the administrator, anæsthesia may be properly carried out by any method. A folded towel drenched with chloroform can be safely used by an anæsthetist who is fully alive to the extreme danger of two or three deep inspirations of a concentrated mixture, and who watchfully secures a free supply of air. On the other hand, a person unmindful of the physiological elements of chloroformisation is a dangerous administrator, however faithfully he may set the taps or turn the handle of the apparatus he may have thought fit to purchase.

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2. *The Application of Food within the System viewed by the Light of Modern Research. By* F. W. PAVY, *M.D., LL.D., F.R.S.*

The most superficial observation suffices to show that the growth and maintenance of the body are dependent upon an adequate supply of food. Life is attended with, and may be said to result from, chemical changes, and a supply of material is required as a medium upon which the change can be brought into play. Building-up and breaking-down processes are constantly in operation, and to meet the demand arising therefrom there must be a supply of food.

It may be taken as an axiom that it is within the tissue molecules that the utilisation of food occurs. The food must reach these molecules and become incorporated as constituent parts of them before it can be turned to account. The manner in which it does so is the point to be considered in this communication.

The doctrine hitherto entertained has been that the products of food digestion enter the blood and by its agency become conveyed to the tissues which take and subject them to direct application. To this doctrine exception will be taken. By modern research a new light has been thrown upon the chemistry of life, and viewed by this light a new aspect is given to the line of procedure connected with the application of food.

Digestion, which constitutes the first step in the preparation of food for service in the system, must now be looked upon as consisting of something more than bringing to a state that absorption by osmosis may occur. It is necessary, it is true, that the food should be liquefied and broken down into small molecules, so as to be rendered diffusible and fit for penetrating the membranous layer of the alimentary canal. It is, however, also necessary that a certain configuration should be given to the molecules to adapt them for being taken on by the cell protoplasm which is instrumental in absorbing and assimilating them. Molecules devoid of adaptability for being linked on to the living protoplasmic molecules would simply pass as inert matter through the body. For instance, cane sugar and milk sugar are not susceptible of being touched by protoplasm. In a dissolved state they are diffusible, and thus can readily pass through an animal membrane; but without transformation as a preparatory step to absorption they would fail to be assimilated, or, in other words, fail to be taken on by the living protoplasm with which

they are brought into relation, and would thus escape contributing any service to the economy.

It is by enzyme action that the requisite adaptability is given for molecular combination, and Nature provides the suitable enzymes for giving to the food molecules the needed configuration for entering into the combination which is implied by the term 'assimilation.' The yeast cell constitutes a representative of living protoplasm; and, as with the protoplasm of the animal being, possesses no aptitude for taking on cane-sugar molecules. By the agency, however, of invertase which the yeast cell produces the cane sugar is transformed into dextrose and lævulose, and these are bodies possessing a molecular constitution suitable for the occurrence of combination with protoplasm.

Thus, by enzyme action provision is made for the food molecules to be placed in a position to become incorporated into the living protoplasm that is located at the seat of absorption. Now, this living protoplasm consists of the lymphocytes which are observable in an actively growing state within the villi whilst digestion is going on. The active growth of these lymphocytes in connection with the digestion period is now recognised as an established occurrence, and their flow into the blood has given rise to the expression 'digestion lymphocytosis' by which the condition is now commonly known.

Digestion, then, prepares not only for absorption, but likewise for assimilation. At the moment of absorption the products of digestion become taken hold of by the lymphocyte protoplasm and built up into an extension of it. Peptone and carbohydrate alike go into lymphocyte growth, and as the lymphocytes are formed they travel through the lacteal system—the channel constructed by Nature for the purpose—into the circulatory system, carrying with them the nitrogenous and carbohydrate constituents of the food. Looked at in this way absorbed food reaches the blood through lymphocyte agency, and the accession of lymphocytes, occurring in association with digestion lymphocytosis, appears from the results of the blood-counting observations that have been conducted to be sufficient to adequately fit in with the circumstances.

After increasing in number for a period of about five hours subsequent to the ingestion of food, the lymphocytes then diminish and fall to their minimum, preparatory to the next intake of food. Taking place in the systematic manner it does, it may be reasonably assumed that the fall is due to a process of autolysis comparable to the autolysis occurring elsewhere. Autolysis is the result of a definite principle of action, and lysins of different kinds, standing in the position of enzymes, are produced to bring about the required effect.

By lymphocyte autolysis the conditions are supplied for the production of the complex proteids of the blood. Fibrinogen, globulin, and albumin must obviously have a source in living protoplasmic matter. They cannot possibly be conceived to take origin otherwise than through the medium of protoplasmic growth. But little attention has been given to this point, and the proteids of the blood seem almost to be dealt with as though they were devoid of any definite source.

A certain amount of experimental evidence has during the last few years been brought forward pointing to the lymphocytes constituting the source of the proteids of the blood; and reasoning upon analogy drawn from collateral considerations there are strong grounds for entertaining the belief that they do so. The gland cells, like the lymphocytes, consist of living protoplasmic matter. They draw their element of growth from the nutrient constituents of the blood as the lymphocytes draw theirs from the constituents of the food. Having performed this office, and brought into play the special attributes belonging to them, they yield up by autolysis their formed material to the secretion which flows away. Growth in the first place, in accord with the specialised attributes existing, and autolysis in the next are cardinal phenomena associated with the manifestations of certain forms of cell life.

The lymphocytes when they reach the blood fall in the comprehensive class of leucocytes. All possess the attributes of living protoplasm. They may be looked upon, I consider, as constituting the living element of the blood by which the standard composition of its plasma is maintained. To leucocytes the office of

phagocytes has been assigned. Is this not a small and merely incidental portion of the duty they perform? As protoplasmic bodies they can take anything that may happen to reach the blood of a nature to be adapted for being linked on to their molecules. In this way they become the assimilative agents of the blood and doubtless nutrient molecules that may have escaped being dealt with elsewhere are here built into protoplasmic matter.

The view that has been put forward assigns to the proteids of the blood the position of affording nutrient matter to the tissues instead of its being given by the transmission of the products of digestion, which, in passing through the blood-stream, would render the blood a chance agglomeration of small molecules that would suffer loss from filtration in passing through the kidney. That the proteids of the blood should stand in the position assigned to them is only in harmony with the position that proteid demonstrably holds in the case of the developing chick in the incubating egg. Here the only material at hand for the tissues to be formed from is the proteid matter within the egg.

From the sketch that has been given of the order of events occurring in connection with the transit of food from its seat of absorption to its seat of utilisation the arrangement summarily expressed stands thus: Food into lymphocytes, lymphocytes into proteids of blood, and proteids of blood into tissue.

The side-chain theory is looked to as affording an explanation of the mode of action in operation in connection with the changes that occur. Under this theory the basis of the protoplasmic molecule consists of a nucleus, and to this nucleus, side-chains, or, as they are called in immunity phraseology, receptors, are attached. Molecules may be linked on to a side-chain and rearrangements occur without the nucleus being disturbed. For linking on there must be a mutual adaptability as regards molecular configuration. If molecules are not fitted by confirmation to join no union can occur. If they are fitted by the exercise of affinity they are drawn together, and it is through what is termed the haptophore group of each molecule that junction is effected. A molecule having been linked on to a side-chain it may through the influence of the other groupings of the chain be acted upon and proceed by steps of degradation, regulated by the particular forces in operation, to utilisation with the development of energy. It is also recognised in the case of foodstuff molecules that they may be linked on to blood protoplasm and subsequently detached by tissue substance, needing nutrient material for growth and renovation. In this way a transport service is performed analogous to that by which oxygen is conveyed by hæmoglobin from the lungs to the tissues. As with oxygen, the tissue taking on of nutrient matter will depend upon the need existing. In a state of tissue-repletion there will be no demand for nutrient matter and no taking-on capacity existing; but with the side-chain material worked off fresh is needed to take its place, and now it may be considered that a tissue-receptor affinity exists superior to that which holds the nutrient molecule in the transport substance, and a change of position is brought about exactly as occurs with the oxygen process that has been alluded to in connection with the matter.

There is a point connected with the application of food to which I have not yet referred. Passage into temporary storage material is what I allude to, and fat and glycogen are the two principles concerned in this process.

Storage fat may be derived from fat-supply with the food. The procedure is a simple one. The fat is prepared by enzyme action for absorption and is taken up by the epithelial cells of the villi. From these it can be traced to the centre of the villus, and then into the lacteal vessels, by which it is conducted to the blood. Reaching the blood, that which is not at once utilised is drawn into cells specially designed for taking and storing it.

Fat is also derived from another kind of food-supply. In former times there was much dispute upon the question of whether fat could be derived from carbohydrate. The point, however, is now regarded as fully settled, and it is recognised that fat is readily and extensively formed from carbohydrate within the animal system. In the fattening of animals the process is carried out as a branch of industry upon a large scale. In my 'Physiology of the Carbohydrates, published in 1894, I entered into the question of the seat of the occurrence of the trans-

formation, and showed that the epithelial cells of the villi and the liver cells are the structures concerned in thus dealing with the carbohydrate of the food-supply. By virtue of the metabolic power located in the cells carbohydrate becomes converted into fat, which shows itself as a visible accumulation in them. Thus, as regards the villi, the lymphocytes build carbohydrate in conjunction with peptone into proteid, and appear to have nothing to do with the construction of fat, whilst the epithelial cells are the agents concerned, not only in absorbing ready-formed fat, but also in forming fat from carbohydrate.

Glycogen is another storage material. It may be regarded as holding an analogous position to fat, and to be produced by cleavage from proteid of superfluous carbohydrate. It is more largely met with in the liver than elsewhere. Doubtless this arises from the liver receiving the food-supply carbohydrate which has escaped transformation into fat and assimilation into proteid in the villi. Examination of the portal blood shows that sugar passes into it when carbohydrate is largely present in the food, and it is well known that the liver glycogen is related in amount to the carbohydrate food-supply. As starch, cellulose, &c., are cleaved off and deposited in vegetable structures, so is glycogen cleaved off, when carbohydrate is redundant, in connection with animal structures. It is simply carbohydrate in excess of immediate requirement, and it is to be found in a multitude of situations, particularly where there is reduced activity. Yeast cells contain glycogen; and it has been noticed that when growing in a 1 per cent. solution of glucose there is only a small amount present, whilst when growing in a 20 per cent. solution there is much.

It is known that under forced severe exercise glycogen disappears, not only from the muscles, but from the liver and its other seats of deposit. For transit from the liver to the muscles, where the consumption occurs, the circulatory system must be traversed, but no evidence is displayed by the urine of the passage of sugar. The view now entertained with regard to the linking on of molecules may be here brought to bear in the way it is applied to foodstuff molecules. Sugar from glycogen may be conveyed in combination in the manner that sugar from food, it may be taken, is done.

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3. *Pathological and Therapeutical Aspects of Adrenative. By* Professor W. D. Halliburton, *F.R.S.*

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4. *A Note on Specific Sera. By* Dr. M. A. Ruffer.

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5. *Report on the State of Solution of Proteids.*—See p. 222.

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6. *Report on the Metabolism of the Tissues.*—See p. 223.

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7. *Interim Report on the Ductless Glands.*

Section K.—BOTANY.

President of the Section—Harold Wager, F.R.S., H.M.I.

The President delivered the following Address at Johannesburg on Tuesday, August 29:—

Introduction.

When Robert Hooke, in the early part of the seventeenth century, discovered, with the aid of his improved compound microscope, the cell structure of plants, he little thought that our ultimate knowledge of the physical and chemical processes in the living organism, of its growth and reproduction, of the problems of heredity and of the factors underlying the origin of life itself, would be in the main dependent upon a clear understanding of the structure and physiology of the cell.

Hooke's researches did not, in fact, carry him very far, and we must turn to the nearly contemporaneous works of Malpighi and Grew on the anatomy of plants for the first clear indication of the important part which cells take in the constitution of the various tissues of plants. The account they give of them is extremely interesting in the light of our present knowledge. Grew, for example, in speaking of the structure of the root, compares the parenchyma to a sponge, 'being a body porous, dilative, and pliable . . . a most exquisitely fine wrought sponge.' The pores are spherical and consist of 'an infinite mass of little cells or bladders. The sides of none of these are visibly pervious from one into another; but each is bounded within itself. . . . They are the receptacles of liquor, which is ever lucid, and . . . always more thin or watery.' There is no indication either in Grew's or Malpighi's works that they understood the significance of this cell structure, and it was not until the beginning of the nineteenth century, after a lapse of some 150 years, that any insight into the real nature of the cell and its functions was obtained. But then began a period of activity—associated with the names of Turpin, Meyen, Robert Brown, Purkinje, J. Müller, Henle, Valentin, and Dutrochet—which culminated in the cell theory of Schleiden and Schwann that the common basis of all animal and plant tissues is the cell, and that it is upon this elementary vital unit that all growth and development depends.

The nucleus was discovered in 1831 by Robert Brown in various tissues of the Orchideæ and in some other families of the monocotyledons, as well as in some dicotyledons. He described it as a 'single circular areola, generally somewhat more opaque than the membrane of the cell,' and more or less granular. It is very distinct and regular in form, and its granular matter is held together by

a coagulated pulp not visibly granular, or, which may be considered equally probable, by an enveloping membrane. Although Robert Brown was the first to recognise the importance of the nucleus, and to give it a name, it had been seen by previous observers, and he himself mentions that he had met with indications of its presence in the works of Meyen and Purkinje, chiefly in some figures of the epidermis; in a memoir by Brogniart on the structure of leaves, and that Mr. Bauer had particularly noticed it in the cells of the stigma of *Bletia tankervilliæ*, but had associated it with the impregnation by pollen. There are some figures by Leeuwenhoek, published in 1719, to which Professor L. C. Miall has called my attention, of blood-corpuscles of a fish, human epidermal cells, and the connective tissue of a lamb, in which nuclei are shown, and they had been seen by Fontana (1781) in epithelial cells, and by Cavolini (1787) in some fishes' eggs.

To Schleiden and Schwann the cell was essentially a membranous vesicle enclosing a fluid sap and a solid nucleus. They thought that it arose in contact with the nucleus as a delicate transparent vesicle which gradually increased in size and became filled with the watery sap. As soon as it was completely formed, the nucleus, having done its work, was either absorbed or cast off as a 'useless member,' or in some cases was 'found enclosed in the cell-wall, in which situation it passes through the entire vital process of the cell which it has formed.' So far from being the most important organ of the cell, as we now consider it to be, they saw in the nucleus merely a centre of cell formation which is no longer required when the cell is formed. It was left for Hugo von Mohl to show that the mucus-like contents of the cell which he called protoplasm (1846) is the real living matter in which reside those activities which call into play the phenomena of life, and that the origin of nuclei by division from a nucleus already existing in the parent cell would possibly be found to occur very widely. Von Mohl, Nägeli, and Hofmeister all appear to have had some idea of the importance of the nucleus in cell division. Von Mohl says that the 'process is preceded in almost all cases by a formation of as many nuclei as there are to be compartments in the mother-cell.' Hofmeister's description of it is interesting: 'The membrane of the nucleus dissolves, but its substance remains in the midst of the cell; a mass of granular mucilage accumulates around it: this parts, without being invested by a membrane, into two masses, and these afterwards become clothed with membranes and appear as two daughter-nuclei.'

It is, however, mainly to the researches of the last thirty years that we owe our knowledge of the many complex cell-activities at work in living organisms, and we are still only just on the fringe of the great problems which cytology has to solve. Some of the most important of these are the origin and evolution of the nucleus, the meaning of the complex mode in which the nucleus divides, the origin and nature of the spindle figure and centrosomes, the part played by the chromosomes in the transmission of hereditary characteristics, the meaning of the phenomena accompanying fertilisation, the significance of the longitudinal division of the chromosomes and of their reduction in number in the sexual cells, and the evolution of the living substance. The satisfactory solution of these problems depends upon a clear understanding of the structure of protoplasm and its various differentiations. How far we have succeeded in obtaining this I will endeavour to show.

The Differentiation of Structure in the Cell.

The essential constituent of a cell is the protoplasm. This is differentiated into two constituents, the cytoplasm and the nucleus. It is usually held that this differentiation is an essential one, and that these two constituents are present in all cells; but, as we shall see later, there is some evidence that not only are there cells with very rudimentary nuclei, but cells in which no trace of a nuclear structure can be found at all.

In addition to this primary differentiation of the cell, secondary differentiations occur, resulting in the production of organs such as chloroplasts, chromoplasts leucoplasts, pyrenoids, and pigment spots, which have special functions to perform

All these are permanent organs of the cell, produced in the first instance as a result of the cell activity, but now capable of an independent existence in the cell, in that they reproduce themselves by division, and are in this way carried on from cell to cell.

In many cells there are formed at certain stages other organs which appear to be transitory, and are only produced when they are required. Such are the spindle figure, the centrosome, the blepharoplast, and the cœnocentrum.

So far as we know, the cell is the smallest vital unit that can have a separate existence. But it is only among the unicellular organisms and under certain conditions in the earlier stages of development of the more highly organised multicellular organisms that cells have a perfectly independent life. Schwann's hypothesis that the multicellular body is a colony of independent vital activities governing the nutrition, growth, and reproduction of the whole is not tenable. The cell cannot be regarded as an independent unity working merely in association with other cells. Its life and existence depend upon these. It is an integral part of an individual organisation, and cannot exist apart from it. But this absolute dependence of individual cells upon the organisation as a whole is only realised in the more highly developed forms. In the lower types of plants (and animals) it is possible, during the early stages of development, to separate a single cell from the whole, which will still continue to live and grow. Each cell is no doubt dependent upon the others to some extent, even at this early stage, but it still retains the power to develop independently if placed under suitable conditions. As cell division continues each cell becomes more and more dependent upon its fellows, until the stage is reached when it no longer has the power to exist by itself. The various functions performed by a cell reside within it as an individual unit, but the exercise of these functions is governed by the organism as a whole. Just as the organism seeks for a state of equilibrium in relation to various external stimuli, so a cell in an organism has to adapt itself to and come into a state of equilibrium with the various cells around it.

The Nucleus.

The nucleus is the centre of activity, and governs the vital functions of the cell. All investigations show that in its absence the cell soon ceases to perform its vital functions and dies.

In all cells, from the algæ and fungi upwards, the nucleus is more or less clearly delimited from the cytoplasm by a membrane or limiting layer. The important substance which is thus separated off from the rest of the cell is the chromatin, probably the most complex and most highly differentiated chemical compound or collection of compounds in the cell. It exists in the form of a more or less granular network, and is characterised chemically by the presence of phosphorus, which is in organic connection with it. We may look upon the chromatin as the highest point in the development of living substance, upon which the activities of the cell in great measure depend, and as the seat of origin of all those complicated changes which have for their ultimate aim the division of the cell.

The division of the nucleus begins by a series of transformations in the chromatin network which lead to the differentiation in it of chromosomes. We know very little of what actually takes place during these changes, and practically nothing of the forces at work to bring them about. But the visible result is that the chromatin granules gradually fuse together, or become restricted to certain areas by the increased vacuolation of the ground substance of the nucleus to form a thick, more or less regular thread, in which can be observed at certain stages a differentiation into alternate regions of stainable and unstainable substance—chromatin and achromatin—which finally breaks up into equal or unequal lengths to form the chromosomes. In some cases the chromatin granules or network become aggregated into a definite number of irregular masses which form the chromosomes directly without the production of a distinct chromatin thread.

This nuclear differentiation is usually accompanied by changes in the

cytoplasm which lead to the appearance of a fibrillar structure in the form of a more or less regular spindle, the threads of which come into contact with the chromosomes through the breaking down of the nuclear wall. The chromosomes then, by the action of a force or forces of which we as yet know very little, arrange themselves in regular order in the equatorial plane of the spindle figure, and some of the spindle fibres become attached to them. The chromosomes become divided longitudinally into two apparently exactly equal halves; and then, probably by the exertion of some sort of contractile force or pull on the part of the spindle fibres, the separate halves are caused to move to opposite poles of the spindle. Here a series of transformations take place, which lead to the constitution of two new nuclei. Such are the essential features in this complex process of nuclear division, and it is a striking fact that they occur with more or less regularity in all nuclei from the algæ and fungi up to the highest plants.

The Structure of Cytoplasm.

In the elucidation of cell structure we owe much to the beautiful methods of staining and fixing which are due especially to Flemming and Heidenhain, to the improved micro-chemical methods which we owe especially to Zacharias and Macallum, and to the investigations of such observers as Fischer and Mann, who have shown us the effects of various reagents upon the living substance, and have thus taught us to be very cautious in our interpretations of the structures seen in dead fixed cells.

The investigations of oil-foams and colloids by Butschli, Hardy, and others have given us a clue to possible explanations of the various appearances seen both in the living and dead fixed and stained cells, and the introduction of the ribbon section cutting microtome into the domain of vegetable histology has enabled us to make the best use of the beautiful apochromatic object-glasses which we owe to the researches of the late Professor Abbé.

It is unfortunate that, so far, very little progress has been made in the examination of the structure of the living cell. We may hope that, with the improved methods of illumination now available, combined with experimental investigation, it will be possible to make some progress in this direction. It is of the greatest importance that we should be able to satisfy ourselves to what extent the various appearances seen in the fixed and stained cell are due to the action of the reagents employed. In this respect a recent discovery by Köhler, which indicates the possibility of making use of the ultra-violet rays in such investigations, is of interest. Köhler ('Phys. Zeit.,' 1904) finds that if the ultra-violet rays from the electric spark between cadmium or magnesium terminals are separated out by means of quartz prisms, objects illuminated by them, when examined by means of lenses made of quartz, show differentiations of structure which otherwise require staining to make them visible. The chromatin of the nucleus and such substances as cuticle and cork are almost opaque to the ultra-violet rays, and can be made visible on a fluorescent screen or can be photographed. The resolving power of the microscope is doubled, and Lummer considers that the principle employed is the only one by which further progress in resolving power can be made. If the method is found by cytologists to be a workable one, it may open up an entirely new field of microscopic investigation by which the protoplasmic differentiation in living cells may be more clearly revealed.

Many attempts have been made to show that the cytoplasm possesses a definite morphological structure of its own, which is related to the various functions it performs, and that it is not a formless semi-viscid fluid in which various physical and chemical forces are at work, and upon which the various structures observed depend; in other words, that it possesses a morphological constitution as opposed to a merely chemical one.

Fromman and Heitzmann in 1875 described the structure of cytoplasm as consisting of fine threads or fibres in the form of a net with fluid between and forming a sponge-like structure. Flemming in 1882 described it as composed of two substances, one in the form of fibrils (filar substance) embedded in the other,

a more or less homogeneous interfilar substance. In 1890 Altmans propounded his interesting hypothesis that all living substance is made up of minute granules or bioblasts, which are the real vital units or elementary organism, embedded in a homogeneous substance, the non-living matter. Cells are formed by a combination of these units of a lower order, and are therefore individuals or units of the second order.

At about the same time Butschli brought forward his celebrated hypothesis of the froth or alveolar structure of cytoplasm. This was based upon an extensive series of observations upon both living and dead cells as well as upon froths or foams made by mixing salts of various kinds with oil and then placing small particles of the oily mixtures so obtained in water.

Butschli compares the structure of cytoplasm to that of a fine froth, and considers that much of the granular, and network or fibrillar structure can be referred to the optical appearances presented by such a froth. That such structures are visible cannot be doubted by anyone who has examined these froths attentively with the microscope. But that all the fibrillar structures described by Fromman and Flemming, whose observations have often been confirmed since by competent cytologists, can be referred to a froth structure, cannot, I think, be accepted by anyone who has carefully examined plant cells.

The microscopical examination of oil-foams is likely to be of great service to us in the interpretation of the appearances seen in the living cell. A fine oil-foam, for example, two or three layers of alveoli in thickness, looks exactly like a piece of granular cytoplasm such as is often seen in cells. Even when examined under the highest powers, the appearance presented is that of a delicate network filled with bright refringent granules more or less regularly spaced, exactly like the granular network so often seen in fixed and stained cells. And yet, as Butschli has shown, there are no granules in the oil-foam; the granular appearance is due to the optical appearance of the meshes above or below those that are in focus. So it may be in cytoplasm: much of the granular structure we see in it, especially when acted upon by reagents or heat, may be due in some measure to the optical appearance of minute alveoli. There are, of course, granular structures in the cytoplasm which have a very real existence, as can be proved by their movements and by their reactions to stains and reagents of various kinds. But staining cannot be taken as a proof of the existence of granules. If an oil-foam be stained by osmic acid we get an appearance of a brownish network containing deeply stained (black) granules, although when a layer only one layer of alveoli in thickness is examined no granules can be seen. It seems to me, therefore, that we have to be extremely careful in our interpretation of structure of protoplasm, especially as seen under high powers of the microscope. It is possible that many of the discrepancies in the accounts given of both cytoplasmic and nuclear structures may tend to disappear if attention be paid to such possibilities as those which are revealed in a careful investigation of oil-foams.

Butschli's hypothesis has received a considerable measure of support owing to the ease with which the appearances described by him can be seen, especially in cells at certain stages of development. Butschli considers that the fine froth-like structure is not to be confounded with the coarser vacuolar structure which is often found. Whether such a difference exists between the coarser vacuolar structure and the fine alveolate structure seems to me difficult to determine. I have examined some hundreds of different kinds of plant cells, both living and in the fixed and stained conditions, and I have never been able to convince myself that there is any essential difference between them. We can easily see, as Wilson has described for animal cells, under favourable conditions, a distinct gradation from the minute alveolate structure, described by Butschli, through all intermediate stages up to the coarser vacuolation of the cytoplasm. And the same is also true of oil-foams. So also we can trace the alveolate structure in cytoplasm from the minute alveoli down to smaller and smaller alveoli, until at last an alveolar structure is no longer visible, even under the highest powers and best illumination which are at present possible. We then get a perfectly homogeneous appearance in the cytoplasm, just as in fresh white of egg.

There are very few cells which do not show a trace of this foam structure at some stage or other in their development. It is very commonly seen in plant cells, and is especially pronounced in cells in which there is any kind of metabolic activity, and is very often displayed in cells in which disintegration is taking place. The cells of the larger Cyanophyceæ frequently show this when they are in the preliminary stages of disintegration. In the actively growing cells of yeast, in the oöspheres of fungi, and in sexual cells of the higher plants, it is commonly well displayed. On the other hand we may often find in vegetative cells, in which there is very little metabolic activity, a complete absence of foam structure. In such cells we can, however, easily cause it to appear by subjecting them to pressure or heat, or to the action of reagents. In cells of living Euglenæ, for example, which are subjected to gentle pressure under a cover-glass, the clear homogeneous regions of the cytoplasm soon become filled with a beautiful vacuolar structure. In some vegetative cells we find that parts of the cytoplasm exhibit a foam structure, whilst others do not: this is no doubt to be associated with local activities in the cell. Such cases can be very easily seen in the cells of the staminal hairs of Tradescantia and the epidermal cells of the leaf.

Strasburger considers that the cytoplasm is of two kinds, which he calls kinoplasm and trophoplasm. The kinoplasm exhibits a fibrillar structure, the trophoplasm an alveolate structure. The kinoplasm is that part of the cytoplasm which is active in the mechanics of cell-division and forms the fibres of the spindle, astral radiations, and such structures as centrosomes and blepharoplasts. The trophoplasm is to be regarded as nutritive in function. The great objection to this hypothesis is that it is only at certain periods in the cycle of changes which the cell undergoes that these structures are visible; at other times the kinoplasm cannot be distinguished from other parts of the cytoplasm, and it cannot be satisfactorily demonstrated that any one part of the cytoplasm is likely to be more active in the mechanics of division than another.

From this brief discussion of the question it is, I think, obvious that we cannot come to any very definite conclusion as to whether a foam structure is an essential attribute of cytoplasm or not. But from the fact that cytoplasm appears homogeneous under certain conditions, and that the foam structure can be so readily produced in it by various means, and further that, as Hardy has shown, the action of certain reagents upon colloids results in the separation of solid particles which become linked together to form a comparatively coarse, solid framework in the form of an open net which holds fluid in its meshes, it is probable that we shall find the foam-structure theory of protoplasm is not tenable. It seems far more in accordance with what we know that we should regard protoplasm as fundamentally a semi-fluid, homogeneous mass, in which, by its own activity, granules, vacuoles, fibrils, &c., can be produced as secondary structures; and that any special morphological structure which it may possess is beyond the limits of the present resolving powers of the microscope.

The Structure of the Nucleus.

From the recent observations of Gregoire and Wygaerts, Berghs, Allen, Mano, and others, it is difficult to arrive at any definite conclusions as to the structure of the nucleus, or as to the changes which take place in it leading to the production of the chromosomes. The resting nucleus seems to possess a very simple organisation. In the living condition it appears to consist merely of a homogeneous ground substance in which is contained a mass of chromatin granules which do not appear to have any particular shape, and one larger granule of a spherical shape, the nucleolus. Sometimes a network or foam structure is visible, but not always; but here, as in the cytoplasm, it is difficult to be certain of this. It may be that the chromatin is always in the form of an irregular network embedded in the colourless ground substance, and that the granular appearance is due to an optical effect similar to that observed in finely meshed oil-foams. According to Strasburger, Miss Sargant, Farmer and Moore, Mottier, and others, the nucleus contains an achromatic network—the linin—in which the chromatin

granules are embedded. Mano, Moll, and Sypkens deny the existence of these two substances, and state that the network consists of chromatin only; while Gregoire and Wygaerts, Allen and Berghs, are inclined to the view that there is a fundamental basis of linin which is impregnated by chromatin ordinarily diffused through its whole substance, but capable of being collected into certain definite regions under certain conditions by which the granular appearance is produced. The evidence brought forward in many of the more recent investigations certainly goes to show that the chromatin is not in the form of such definite granules as was at one time supposed; that they are not so regular in size or outline; and that it is not easy to differentiate between the chromatin and achromatin contents of the nucleus. Staining reactions do not afford a sound clue to their differentiation, for, as Fischer and, more recently, Allen have shown, the differences in staining reactions of the different parts of the nucleus vary according to the strength of the stain, the time it is allowed to act, and the size or thickness of the granules or threads stained.

Strasburger has suggested that the chromosomes are formed by the fusion of gamosomes (chromatin granules) around gamo-centres into zygosomes (chromosomes), but the changes which take place are probably not so clearly defined as this. What seems clear from the facts we know is that the substance forming the homogeneous chromosomes—the chromatin or nuclein—becomes broken up in the reconstitution of the daughter-nuclei, by vacuolation or otherwise, into an irregular network which presents a granular appearance. In this all trace of the original individual chromosomes is in most cases lost, and at the same time one or more deeply staining bodies of a spherical, or nearly spherical shape—the nucleoli—appear in contact with it.

The Nucleolus and its Function.

The evidence is steadily accumulating that the nucleolus is intimately concerned in the formation of the chromosomes, although probably not exclusively concerned in this function. In most cases it appears to form a part of the chromatin network, being connected to it by threads and generally gives similar reactions to the chromosomes. In some few cases it is described as completely separated from the network by a clear area which is visible both in the living and in the stained condition. The evidence that the nucleolus is concerned in chromosome formation may be summed up as follows: the nucleoli are closely connected or associated with the nuclear network; as the nuclear network becomes more deeply stained the nucleoli become smaller or lose their capacity for stains; at the time the chromosomes are being differentiated they are connected to the nucleoli by delicate threads; the chromosomes resemble nucleoli in their behaviour towards reagents and stains; during the period of sinapsis the nucleoli come into very close relations with the nuclear thread, and as the nucleus gradually passes out of the sinaptic stage the thread stains more deeply; in the reconstitution of the daughter-nuclei the chromosomes can be seen to fuse together into a more or less irregular mass, out of which the delicate nuclear network and the prominent nucleolus are evolved; in certain cases all the chromatin appears to be stored up in the nucleolus.

It has been suggested that the nucleolar substance is a product of excretion of the nucleolus, but there is very little evidence for this view. On the other hand it is very likely, as suggested by Mottier, that the nucleolus contains a store of nutritive material which can be used up for various purposes, both in the nucleus and in the cytoplasm. In some cells a portion of the nucleolar substance is thrown out into the cytoplasm during the division stages, and it is very probable that this may have some important connection with the metabolic activity of the cell at this period. Miss Ferguson points out, for example, that it is extremely probable that a portion of the nucleolar substance of the egg nucleus of *Pinus* becomes transferred into the cytoplasm, where it gives rise to the proteid vacuoles or nutritive spheres of the oösphere. The same phenomena are also observable in Gingko, according to Hirase, and have been noticed by other observers. In

the zygote of *Polyphagus euglenæ* I have observed that a large portion of the nucleolar substance of both the sexual nuclei passes out into the cytoplasm, and there in some way assists in the production of the oily reserve substance which appears in it. It is also possible that, as Strasburger suggests, it may be concerned in some way in the formation of the nuclear spindle either by actually providing substance for its formation, or, what is perhaps more likely, by setting up certain changes in the cytoplasm which lead to its aggregation into fibrillæ.

If the chromatic material of the nuclear network and nucleolus is the most highly organised of all the living constituents of the cell, it is probably intimately concerned in all the important activities of the cell, whether they lead to the storing up of reserve substances, or to the expression of the special activities of any particular cell, or to the production of those special modifications of the nucleus and cytoplasm by which the division of the cell is brought about. The function of the nucleolus may thus very well be simply that of a reserve of this highly complex chromatin which can be drawn upon as occasion requires. If we consider it in this light it will, I think, be found much easier to understand its relation to the complex changes which take place in the nucleus during division than if we regard it as a definite organ of the cell with a special function to perform.

Division of the Nucleus in the Spore Mother-cells.

The divisions of the nucleus which lead immediately to the formation of the spores possess some features which are not found in ordinary vegetative mitosis, and which have an important bearing upon the facts of heredity. The first of these is known as the heterotype, the second as the homotype division. The essential features of the heterotypical division are as follows: The chromatin net becomes gradually resolved into a more or less continuous spireme. This thread (or threads) contracts into an irregular mass around the nucleolus, a phenomenon which was first discovered by Moore, and to which he gave the name of 'sinapsis.' Some observers regard this contraction as caused by reagents; but since it has been observed in the living condition by Miss Sargant and others, it is probably a definite and normal stage in the division. It is concerned with some very pronounced changes which take place at this time in the nucleus. The nuclear thread becomes more prominent, stains more deeply and exhibits a double row of granules which gives it the appearance of a double thread. This has been variously interpreted by different investigators: Miss Sargant, Farmer and Moore, and many others consider that it is due to a longitudinal splitting of the thread; Dixon, Gregoire, Berghs, and Allen consider it as indicating a close approximation of separate loops of the thread. Whichever of these explanations is the correct one, the doubling gradually disappears and the thread becomes distributed through the nuclear cavity and again appears single; it becomes shorter and thicker and once more becomes aggregated around the nucleolus. This may be, as Miss Sargant suggests, a second sinapsis. At this stage the chromosomes appear, but reduced to half the number of those which appeared in the previous divisions, so that they may be regarded as bivalent or double chromosomes. They become shorter and thicker, and gradually become grouped in the equatorial plane of the nucleus, where they become attached to the spindle fibres. Each chromosome now divides into two halves, which pass to the respective poles of the spindle, to form, without the intervention of a complete resting stage, the division figures of the daughter-nuclei.

The exact mode in which the division of the chromosomes into two halves takes place is the subject of much controversy. The studies of Weissman on the phenomena of heredity led him to the conclusion that the chromosomes consist of more than one complete ancestral germ-plasm, and that consequently these must be reduced in number in the sexual cells to escape the extraordinary complexity which would arise if the ancestral germ-plasms were doubled at each sexual fusion. As the longitudinal division of the chromosomes divides them into two equal halves it is obvious that this will not reduce the number of ancestral

germ-plasms, and therefore Weissman predicted that a transverse division of the chromosomes would be found to take place by which the reduction would be brought about. This was soon discovered to be the case for many animal cells, the reducing division taking place during the formation of the sexual cells, but in plants this was not so easily determined. Belajeff, Dixon, Atkinson, and others maintained that a true reduction division took place in the cases examined by them; but the majority of observers, Miss Ethel Sargant, Strasburger, Farmer, Mottier, and many others, maintained that there was no transverse division, but that all the divisions were longitudinal. Recently, however, Farmer and Moore have reinvestigated the whole sequence of events in both animals and plants, with the result that a true reduction division is found to occur in the heterotype stage. In many investigations which have recently appeared this transverse division is confirmed, but the exact details of the process are not yet agreed upon. Farmer and Moore state that the spireme thread first becomes longitudinally split, the two longitudinal halves then fuse again, and subsequently bivalent chromosome loops are formed which divide transversely in the middle, and so produce two monovalent chromosomes which pass to opposite poles of the spindle, as already described. Gregoire, on the other hand, states that the threads at the first sinapsis become approximated together and then fuse; the double thread thus produced breaks up into chromosomes, which are thus bivalent in a different sense from those of Farmer and Moore, the monovalent chromosomes being produced by a longitudinal splitting of the thread, which divides it into the two original halves which fused together.

Which of these two methods will ultimately be found to be the correct one remains to be seen, but Allen has recently published an account of the process as it occurs in *Lilium canadense,* in which he agrees substantially with Gregoire, and states definitely that the first appearance of the double nature of the thread is not due to a longitudinal splitting of a single thread, but to an approximation of two threads, which ultimately fuse together to form a single continuous thread in the nuclear cavity. This thread at a later stage undergoes a longitudinal splitting, possibly into those which formerly united; but this is not certain. The double thread then divides up into segments, the chromosomes, and in the subsequent series of events the longitudinal halves of these chromosomes become distributed to the opposite poles of the spindle. Each chromosome is thus seen to be bivalent; but whether each half of the chromosome is to be regarded as a monovalent chromosome is doubtful, as the fusion of the original threads was complete, and there is no means of deciding as to how far the subsequent longitudinal division of the completely fused thread separated it into its two original parts.

Allen expresses the opinion that the characteristic peculiarities of the heterotype division are due to the formation of two distinct spirems, which contain the substances derived respectively from the male and female parents. The two spirems fuse together into a single thread in the sinaptic stage, and thus bring about an intimate association of the male and female hereditary substances which were brought together by the fusion of the germ-cells thousands of cell generations previously.

This view is, of course, so totally different from that of Farmer and Moore, Strasburger, and others, that further investigation is necessary before we can come to any precise conclusion concerning the nature of the heterotypical division. Allen's suggestion opens up an extremely interesting problem in cytology, and one which is intimately bound up with recent views on heredity.

Sinapsis.

The term 'sinapsis' was first given by Moore to that stage in the prophases of the nuclear division of the sexual cells in which the contraction of the nuclear thread around the nucleolus at one side of the cavity of the nucleus takes place. If this phenomenon is not a result of the action of the fixing reagents, then it indicates some striking change in the metabolic activity of the nucleus. This

activity is seen in the increased staining capacity of the chromatin thread and in the changes which take place in the nucleolus, by which it becomes very irregular in shape and closely connected by threads to the chromatin network. In many cases the nucleolar substance appears as if being drawn out into the threadwork, and the nucleolus appears as if some active change were taking place in it.

It is very difficult to escape the conclusion that we are here dealing with a series of changes in the chromatin thread which are intimately bound up with the activity of the nucleolus, and it is probable that the increased stainability of the chromatin is due to an actual transference of a portion of the nucleolar substance into the thread.

We know very little of the causes which bring about the rearrangement of the nuclear substances which lead to the formation of the chromosomes. The regularity of the sequence of events in the process seems to me to preclude the possibility that they are due merely to changes set up by the action of reagents. It is very probable that the metabolic activity of chromatin itself, and possibly of that part of it which is stored up in the nucleolus, plays a significant part in these phenomena. Sinapsis, for example, may be set up by diffusion currents between the nucleus and the surrounding cytoplasm, brought about possibly by the secretion of nucleolar or chromatin substance, or to interactions taking place between it and the cytoplasm.

Experimental Observations on the Activities of the Nucleus.

So far as I know no experimental investigations into the causes which bring about the changes in the prophases of nuclear division have been made, but it is not difficult to imitate artificially some of the phenomena observed. Olive oil is shaken up in a mixture of methylated spirit and water of such a strength as will allow the oil globules to float. A shallow petrie dish, three or four inches in diameter, is then taken ; the mixture of oil and dilute methylated spirit is well shaken until the oil is broken up into very fine globules, and the mixture is at once poured gently into it. The appearance of the mixture is that of a homogeneous mass of small oil-globules distributed through the solution, and can be compared to the granular appearance of a nucleus in a resting stage. The spirit at once begins to evaporate, and currents are at once set up in the solution in such a way that the globules of oil gradually become restricted to certain areas only, and a coarse granular network is formed somewhat like the early stages in the aggregation of the chromatin granules into a spireme in the nucleus. The network gradually becomes more and more clearly defined, and then, just as is the case in the nuclear network, it begins to show a double row of granules, which finally becomes very clear and distinct. The threads become shorter and thicker and break up into irregular lengths, which gradually mass themselves together into an irregular heap or heaps of fusing oil-globules either in the middle or at the periphery of the petrie dish. We have, in fact, a good imitation of the earlier stages in the prophases of division of the nucleus, and it seems not unlikely that the aggregation of oil globules in our petrie dish may afford some clue as to the possible means by which the aggregation is brought about in the nucleus.

I do not suggest that the complex phenomena which take place in nuclear division are to be explained as due simply to such phenomena as diffusion, surface tension, and the like, or any other physico-chemical processes. We must be very careful not to attempt to force merely physico-chemical explanations upon such phenomena as these. Without admitting the necessity of anything akin to a special vital force, we are compelled to admit that vital phenomena do not at present admit of a merely mechanical explanation. But it does seem to me possible that the metabolic activity of the nuclear material at this stage may be accompanied by phenomena referable in part to these agencies. If, for example, active metabolic activities are set up between the nucleus and cytoplasm through the nuclear membrane, as seems probable, it is quite conceivable that this would bring about diffusion currents which might be taken advantage of in producing the aggregation of the more solid parts of the nuclear substance into a more

or less definite thread-like structure and its aggregation into chromosomes. In any case such possibilities must be taken into account in considering the significance of such nuclear rearrangements, and if any of them can be definitely explained in this way the final solution of the problem may be much simplified.

As Professor Jennings points out, 'anything which promises a bridge from the inorganic to the organic, from the physical to the vital, demands attention.' Such experimental investigations pave the way for further progress, and, if carefully considered, 'must result finally either in the discovery of the real factors at work, or in the recognition that we are dealing with a new class of factors not found in physics.'

Validity of Cell Structure as seen in Fixed and Stained Preparations.

Our knowledge of the minute details of cell structure and nuclear differentiation depends upon the appearances presented by cells which have been fixed in various reagents and subsequently stained, and it is not an easy matter to determine in how far these are artificial and in how far they are actual structures existing in the living cell. The researches of Fischer, Hardy, Mann, and others have shown that on the precipitation of proteids by reagents structures are produced which were certainly not present originally, and which resemble those often observed in fixed cells. From a consideration of such facts it has been suggested that many of the details revealed in fixed cells, such as centrosomes and centrospheres, with their fibrillar radiations, are produced artificially and have no real existence. It is unfortunate that so little attention has been paid to the examination of living cells, for the structures which can be seen in them are, so far as they can be revealed by the microscope, always like those seen in fixed preparations.

Differentiation of Structure Visible in the Living Cell.

The amount of differentiation visible in the living cell in favourable objects is very considerable. Not only can chloroplasts, starch-grains, nucleus, leucoplasts, pyrenoids, &c., be clearly seen, but also a very considerable amount of detailed structure. Chromosomes have been seen in the living cell by many observers—Treub, Strasburger, Behrens, Zacharias, and others. The series of figures published by Strasburger of nuclear division in the staminal hairs of Tradescantia show the whole process of chromosome formation and separation into two daughter-groups, except the longitudinal division.

In the same object Demoor and de Wildeman have also been able to detect the spindle fibres and connecting fibres. These were not seen by Strasburger; and Zacharias, who has more recently made observations on staminal hairs, was also not able to detect them. Nevertheless Strasburger mentions that in some cases connecting threads were visible at a late stage in the division between the daughter-nuclei, and Treub also describes a similar phenomenon in some cases during the nuclear division in the ovules of an orchid.

In Spirogyra, Strasburger has given a full account of nuclear division in the living cell. Large species of this alga are very favourable objects for this work, and he has shown that in such species the spindle figure as well as the connecting fibres can be seen in the living cell. Wildeman has also seen and figured them; but Behrens states that spindle fibres and connecting threads are not visible in Spirogyra during life.

My own observations upon a large species of Spirogyra which I have had an opportunity of investigating entirely support the view that these structures are visible in the living condition. The resting nucleus is large, and contains a large pale refringent nucleolus (sometimes also a smaller one) which sometimes appears granular; the cavity of the nucleus is filled with a homogeneous-looking substance which appeared in some cases to be finely punctate or granular. The nucleus is surrounded on all sides by a granular cytoplasm the granules of which are in constant motion, especially just previous to nuclear division; it is suspended to

the cell wall by delicate strands of cytoplasm, also full of moving granules. The first indication of division is shown in the accumulation of cytoplasm around the nucleus and the gradual disappearance of the nucleolus; at the same time the originally somewhat oval or spindle-shaped nucleus becomes rectangular in shape whilst the nucleolus disappears entirely. Shortly after this the nuclear plate appears as a pale refringent structure, just like the original nucleolus, but of a different shape. As the nuclear plate is formed the homogeneous substance in the cavity of the nucleus presents a finely striated structure on each side of the nuclear plate and at right angles to it extending to both ends of the nucleus. The nuclear membrane becomes indistinct; the nucleus elongates and an accumulation of granular cytoplasm begins at its two ends or poles.

The nuclear plate then divides, and the two halves begin to move apart; the accumulation of cytoplasm at the poles becomes more prominent and appears to be closely connected to spindle fibres attached to the two halves of the nuclear plate. The spindle fibres gradually become shorter, but I could not detect any appreciable thickening of them. The impression conveyed to my mind was that the substance of them was being absorbed into the mass of cytoplasm at the poles, which was now rapidly increasing in size and forming very distinct polar caps. Shortly after the two halves of the nuclear plate had begun to move towards the poles the connecting threads became visible between them, and in the later stages of division became very prominent, less numerous, and thicker, probably by fusion, but I could not be certain of this. When the flat halves of the nuclear plate reach the poles they contract into somewhat irregular oval-shaped masses, the daughter-nuclei. These become more definite in outline; a nucleolus appears in each, a nuclear membrane is then formed, and the daughter-nuclei are thus completed.

This does not of course give us a complete picture of all the details visible in fixed and stained specimens, but sufficient to show that the more important features of mitosis have a very real existence, and are not due to reagents.

The Structure of the Chloroplast.

In view of its extreme importance in the function of assimilation a knowledge of the structure of the chloroplast is important. Owing to its small size a satisfactory demonstration of its finer structure is very difficult. That it consists of a colourless ground substance, in which the chlorophyll is embedded, is clear; but how these two substances are united and the relations between them structurally are not known. Pringsheim concluded that the ground substance of the chloroplast is a sponge-like network with the oil-like solution of chlorophyll in its meshes.

Schmitz thought that the fine granular appearance of the chloroplast was due to a fine net-like structure in which the chlorophyll was diffused. Fromman also describes it as a green granular network. Schwartz, on the other hand, describes it as composed of a ground substance containing a number of green fibrillæ side by side, which are coloured green throughout, but show also an accumulation of the green colouring matter in the form of granules along these threads.

Meyer thought it was composed of a homogeneous ground substance with various-sized granules of the green substance embedded in it. To these granules he gave the name of 'grana.' Schimper stated that it was composed of a colourless stroma containing numerous vacuoles filled with the green semi-fluid chlorophyll, identical with the 'grana' of Meyer.

Some observers consider that the chloroplast is surrounded by a distinct membrane; whilst others consider that the substance of the chloroplast is directly connected by colourless strands to the cytoplasm.

According to some observations which I have recently made, the chloroplast, when examined under high powers in the living condition, appears to be filled with a mass of green granules with a colourless substance between them. But in certain cases a distinct fibrillar arrangement of the chlorophyll is observed. This is very easily seen in the chloroplasts of *Euglena*, both in the living condition, and, more easily, when the cells are burst and the chlorophyll grains are

extruded into the water. But it may be seen also in the chloroplasts of the higher plants when these are large enough to be examined easily. In these cases the green colouring matter appears granular when the chloroplast is in the epistrophe or shade position, fibrillar when it is in the apostrophe or intense light position. This difference in the appearance of the chlorophyll accompanies a difference in the shape of the chloroplast. As is well known, the chloroplast in the epistrophe position presents an oval or more or less circular form; in the apostrophe position a flattened and lenticular form. The fibrillar structure appears to be that of fine fibrils lying more or less parallel, but a closer examination shows that they are connected together here and there so as to give the impression of an elongate network. In the epistrophe condition the chlorophyll corpuscle appears greener than in the apostrophe condition. The granules are in fact so arranged and so numerous as to present a practically continuous surface of chlorophyll to the action of the light rays. The fibrillar arrangement, on the contrary, has numerous light spaces between the fibrils, so that less surface of chlorophyll is exposed to the rays of light. The difference in the amount of chlorophyll surface exposed to the light appears therefore to be bound up with the difference in the intensity of light which causes the different positions of epistrophe and apostrophe to be assumed by the chloroplast. Just as in diffuse light the chloroplasts themselves are more fully exposed to the light than in intense light, so in the individual chloroplast we appear to have such an arrangement of the chlorophyll that in diffuse light a larger surface of it is exposed to the light rays than in a more intense light. The interesting conclusion is therefore arrived at, that the chloroplast is able, not only by its position but also by its structure, to guard itself against the effects of a too intense light.

A careful examination of the chloroplast in the epistrophe position renders it probable that the granular appearance is not due to the existence of separate granules of chlorophyll. It resembles more nearly an optical effect, due to the superposition of alveoli upon one another, such as appears in fine oil-foams. By focussing carefully above and below the granules we get a distinct appearance as of a green alveolar network. If the chlorophyll corpuscle is extruded into water it begins to swell up and becomes vacuolar; the granules disappear and the chlorophyll then appears to be distinctly diffused through the ground substance of the chloroplast. I am therefore inclined to the view that the chlorophlyl corpuscle consists of a ground substance in the form of a delicate alveolate structure, in which the chlorophyll is more or less uniformly diffused. The diameter of the threads of this network is greater in the epistrophe than in the apostrophe position, and this affords a means by which the chloroplast can accommodate itself to varying intensities of light.

The chloroplast must be regarded as performing at least two functions. It brings about the dissociation of CO_2 and it is a starch-forming organ. In the algæ and some other plants these two functions appear to be differentiated, and starch is formed directly by the pyrenoid. How far these two functions are independent in the ordinary chloroplast is not known; but that starch can be formed, independently of chlorophyll, in the leucoplasts and in the ordinary chloroplasts directly from sugar and other organic solutions in the dark seems to indicate that the two are not necessarily connected.

The colourless stroma of the chloroplast gives a distinct and pronounced reaction for phosphorus when treated according to Macallum's method. It resembles, therefore, in this respect the nuclein constituent of the nucleus. What the exact significance of the presence of phosphorus in the chloroplast may be I do not know, but it is extremely interesting to find that in an organ in which a high degree of metabolic activity is always found a substance should be present which is akin to the highly organised nuclear constituents. It suggests an interesting comparison with those plants in which a special starch-forming organ, the pyrenoid, is differentiated. For the pyrenoid, as Macallum has shown, and I am able to confirm, gives a strong reaction for phosphorus, whilst the chromatophore with which it is associated gives but a slight reaction for this element. This seems to indicate that the starch-forming function is bound up with the presence of phosphorus

in the chloroplast, where it may exist in a form similar to that of the nuclear material, chromatin. If we connect this with the fact that in many cells in which large quantities of reserves are stored up there is, previous to their formation, a migration of nuclear substance into the cytoplasm, the hypothesis is at once suggested that the pyrenoids and chloroplasts may not be merely cytoplasmic differentiations, but that in their original formation phylogenetically the nuclear substance may have had a share.

The Centrosomes and Centrospheres.

A vast literature has grown up in connection with the structure and function of these bodies because of the special importance which has been attached to them as the originators of the process of nuclear division and of the formation of the spindle, and because of the important part which it is assumed they play in the phenomena of fertilisation.

Their very general occurrence in animal cells and their prominence in the reproductive processes led plant cytologists to predict that they would be found to occur also in plant cells. But their prediction has not been fulfilled. They are frequently found among the Thallophytes and Bryophytes, but in the higher plants the evidence is steadily accumulating against them, and such structures as have been described by Guignard and others are held to be based upon a misinterpretation of the facts observed.

Where the centrosome exists it consists of a deeply stained granule or group of granules surrounded by radiating fibres. In some cases, as in the Basidiomycetes, the centrosomes only become definitely visible as minute dots at the poles of the spindle, and are not visible until this is completely or nearly completely formed. In other cases, as in Dictyota (Mottier), Ascomycetes (Harper), the centrosomes with their radiations are clearly visible at two opposite sides of the nucleus in the resting stage, and are in close contact with the nuclear membrane. In the Ascus, Harper has shown that the centrosome is in close contact, not only with the nuclear membrane, but also with the chromatin net, and it seems probable that there may be a connection between them. The spindle fibres are formed both in Dictyota and in the Ascus in the nuclear cavity before the nuclear wall breaks down. In the division of the daughter-nuclei the centrosome which is carried over with each daughter-nucleus appears to divide—but this is not certain—to give two new centrosomes for the formation of the new spindle figure.

From some unpublished observations of my own on *Polyphagus* the centrosomes appear at the poles of the nucleus in the same position as in the nuclei of the Ascus, and give rise to intranuclear spindles; but I have not so far been able to detect that they are continued from one division to another. They seem to disappear at each division stage and to be formed anew by a condensation of stainable substance in contact with the nuclear membrane, as the mitotic stage again approaches.

In some plants instead of a clearly defined deeply stained controsome there are found at the poles of the spindle larger and more diffused cytoplasmic condensation called centrospheres. It is not probable that these represent structures morphologically different from centrosomes. They are probably of the same nature and perform the same functions.

The centrosome and astrosphere are concerned in some way in the production of the spindle figure. Whether they must be regarded as the originators of the spindle, or whether they are merely the result of the condensation of forces at work in the cell, is a question which at present is not decided. That they are not essential to the production of the spindle figure is proved by the fact that they do not exist in the higher plants. In these cases the spindle formation is associated with the accumulation of cytoplasm in the form of cytoplasmic caps at the poles of the nucleus, from which the spindle fibres penetrate the nuclear cavity; or, especially in the spore mother cells, from a weft of fibres which accumulates around the nucleus. These fibres become grouped together to form a

multipolar spindle, and these gradually approach until the spindle is approximately bipolar.

The differentiation of the spindle figure appears to be entirely for the purpose of bringing about the separation of the split halves of the chromosomes. As to the exact mode in which the spindle is formed, or the forces which bring it about, and the nature of the spindle itself, these are problems which as yet remain unanswered.

Experiments on the Production of Artificial Asters.

There are two main views as to the nature of the spindle and astral fibres: (1) that they represent a definite morphological differentiation of the cytoplasm which possesses in itself the power of forming these fibres; (2) that they are formed out of the cytoplasm by some modification of its structure or arrangement of its parts, or by the precipitation or condensation of some of its constituents.

The aggregation of granules into radiating fibrils can be imitated artificially by allowing a drop of alcohol or turpentine to fall upon smoked glass. If the drop is allowed to fall from a good height, we get the artificial centrosomes with radiations first described by Henking; these are due mainly to the splash of the drop and its breaking-up into small particles which radiate outwards, carrying portions of the smoke film with them. If the drop is allowed to fall more gently, so that it does not splash, its first effect is to produce a clearly circumscribed circular ring, and then, by slowly spreading outwards, to produce an aggregation of the smoke particles into fibrils which more nearly represent the appearances produced in cytoplasm than do Henking's splashes.

By careful manipulation we can get in this way representations of the centrosome or centrosphere, or even the radiations around the nucleus. If the edge of the alcohol or turpentine be carefully examined under the microscope as it is slowly spreading outwards, a violent motion of the smoke particles will be observed as soon as the liquid comes into contact with them, and as the liquid passes on these particles settle down into definite continuous fibrils, which go on growing as the liquid continues to spread. Although I do not wish to push the analogy too far, it seems to me that in the same way the excretion of a liquid from the nucleus or centrosome into the cytoplasm may set up surface-tension phenomena of a complex character which would lead to the aggregation of the granular cytoplasm into radiating fibrillæ, or to the precipitation or coagulation of the proteid substances with a subsequent fibrillar aggregation. In any case the possibility that it is due to some physico-chemical changes brought about by the active metabolism of the nucleus or cytoplasm is not excluded, and it is much to be desired that this field of experimental investigation should be more fully explored.

Fischer has described the formation of artificial asters by two methods: (1) If pith is injected with proteid and then fixed, asters are found around small particles of foreign matter in the proteid. (2) If a small granule of corrosive sublimate or a drop of osmic acid be brought into a proteid solution radiating striæ are formed in it by precipitation. He suggests that the centrosome is formed by the precipitation of albuminous substances in living cells by the excretion of nucleic acid from the nucleus, and that, as in (1), artificial radiations are formed around it by the action of the fixing reagents; or possibly by the fixative action of the nucleic acid itself. Or the centrosome itself may produce them, as in (2), by acting as the precipitating agent, just as corrosive sublimate or osmic acid. Mr. Jenkinson has recently described some interesting experiments on the artificial production of asters, and comes to the conclusion that osmotic pressure and surface tension are probably concerned in the formation of these structures in the living cell. The centrosome may be a body capable of withdrawing water from the cytoplasm, of swelling up and dissolving in the water so absorbed, and then giving off radial outgrowths which precipitate the proteids of the cell, and so form astral rays; or the centrosome may undergo decomposition, or may secrete a ferment which would have the same effect upon the cytoplasm.

The Blepharoplast.

The blepharoplast is a special organ associated with the formation of the cilia in motile spermatozoids and zoospores. It consists of a centrosome-like granule, often surrounded by radiations. It appears inside the cell in close relation to the nucleus, or sometimes at the periphery of the cell. In Polytoma the two cilia thus arise from a granule (blepharoplast) at the extremity of the cell. In Ædogonium the blepharoplast arises, according to Strasburger, in the plasma membrane. Strasburger considers them as kinoplasmic in nature, and thus brings them into relation with his other kinoplasmic structures, the centrosome and spindle.

In Zamia the blepharoplasts appear in each sperm cell on opposites sides of the nucleus and at some distance from it. They are large, well-marked, deeply stained bodies, with distinct radiations, and might easily be regarded as centrosomes. They break up into granules, which come into contact with the nucleus, and gradually arrange themselves as a spiral band at the periphery of the cell from which the cilia arise. Similar phenomena are observable in Cycas and Gingko. Our knowledge of these is largely due to the researches of Webber, Ikeno, and Hirase. In the Filicineæ, Equisetaceæ, and Hepaticæ, according to the researches of Belajeff, Shaw, Ikeno, and Strasburger, we have similar results.

Some authors consider that the blepharoplast is a true centrosome, or homologous with a centrosome. It has not, however, been conclusively shown that it at any period in its history performs the function of a centrosome, or that it is derived from one. Further, in many of these plants, if not all, there are no centrosomes at any stage in their life history.

On the whole the evidence is distinctly against the view that the blepharoplast is genetically connected with the centrosome. It is more in accordance with the present state of our knowledge to consider the blepharoplasts as special structures which arise *de novo* in the cell for the special function of cilia formation.

The Cœnocentrum and its Function.

In the oögonia of some fungi there appears at an early stage in the development of the oösphere a dense granular, deeply stainable substance, the function of which is unknown. It appears in the centre of the cell, and was first discovered in the oösphere of *Cystopus* (*Albugo*) *candida.* It is probably formed by an accumulation of stainable granules or microsomes. It disappears soon after fertilisation takes place, and is therefore not a permanent organ of the cell. Shortly after its appearance one of the nuclei out of the large number irregularly scattered through the oögonium comes into contact with it, and gradually becomes more or less embedded in it. All the other nuclei pass to the periplasm, leaving this single nucleus as the nucleus of the ovum. The fertilising tube which contains the male nucleus also grows towards it, and comes close to it to discharge the male nucleus upon it. This indicates that it may exert in some way or other an attraction, first upon the female nucleus, and secondly upon the fertilising tube, thus helping to bring the sexual nuclei together. Stevens suggests that it may be of the nature of a dynamic centre, and he gave it the name *cœnocentrum.* It may be nutritive in function, and may exert a chemotactic stimulus upon the sexual nuclei.

It does not appear to be actually concerned in the fusion of the sexual nuclei. In *Peronospora parasitica*, for example, it completely disappears before the fusion of the nuclei takes place. So far all the views as to its function are purely hypothetical. It may be a mere coincidence that it should become associated with the sexual nuclei at the time they come together in the oösphere. Its function may be totally unconnected with these. From the fact that it stains so deeply in nuclear stains, the substance of which it is composed may be of the nature of nuclein, and it is possible that it may be due to a substance secreted by the nuclei of the oögonium for some special purpose connected with the maturation

of the oöspore. It is possible that it may have something to do with the formation of oil, which appears in such abundance in the ripe oöspores. It begins to disappear just at the time the oil begins to form. The oil at this stage is only present in small drops, but soon after its disappearance a large quantity of oil appears. It is well known that fats, as well as other non-nitrogenous bodies, may appear as decomposition products of proteids. There is nothing, therefore, to preclude the possibility of the cœnocentrum being associated with the formation of the fatty substances of the oöspore. Some phenomena which have been observed by me in the maturation of the zygote of *Polyphagus* support this view. After fertilisation has taken place the two nuclei, although they come into close contact, do not fuse, but separate to opposite sides of the cell. They are large and prominent at this stage, but they gradually become smaller, and a part of the nucleolar, or, as it is in this case, the chromatin contents, become extruded into the cytoplasm to form a granular mass around each nucleus. The two nuclei then approach again, and the two masses of nucleolar chromatin become united in the centre of the cell to form a large spherical mass of deeply staining granules, with the two nuclei, which are now very small, embedded in it. It is probable that this body is of the same nature as the cœnocentrum. It stains deeply in hæmatoxylin, and it also gives a strong reaction for phosphorus, which indicates its nuclear origin. It soon begins to disappear, and in place of it we find an irregular globular mass of oil or oil globules.

From a consideration of these facts it seems to me far more likely that the function of the cœnocentrum is connected with those metabolic activities of the zygote, which must at this stage in its development be very considerable, than with the exertion of an attractive influence upon the sexual nuclei. It is difficult to see how such a selective chemotactic stimulus could be exerted as to act upon one nucleus only out of the large number in the oögonium. But the evidence before us does not admit of any definite solution of the problem at present. The subject demands further investigation of such a kind that a comparative study of the formation and disappearance of the cœnocentrum, the formation of the oil reserves, and the changes in the nuclei, should be carried on side by side.

The Nuclei of the Lower Plants.

The presence of nuclei in the algæ and fungi had already been recorded by Nägeli and many other observers shortly after the discovery of the nucleus by Robert Brown, but it is doubtful whether all the structures described as nuclei by these early observers were really so. It is only in comparatively recent times that it has been possible to determine with any degree of certainty that the minute deeply stainable bodies described more especially by Schmitz (1879) could be regarded as nuclei. This determination was easily made for many of the algæ, especially by the researches of Strasburger, who described both the structure and mode of division. But among the fungi the structure and mode of division of the nuclei were practically unknown twenty years ago, and we have the opinion expressed by De Bary in 1887 that the satisfactory discrimination of true nuclei from other small bodies contained in the protoplasm can only be obtained after renewed investigation.

Previous to 1887 cases of karyokinetic division in fungi had been described by Sadebeck (1883), Strasburger (1884), Fisch (1885), and Eidam (1887). Hartog (1889) described a process akin to karyokinesis in the Saprolegnieæ, and at the end of that year a true process of karyokinesis was shown to occur in Peronospora. Since that time our knowledge of the process of nuclear division in the fungi has been largely extended, and the phenomenon has now been found to be of general occurrence in the group, and many of the forms are unusually favourable objects for the study of the process.

The only groups of plants in which true nuclei have not been found are, so far as I know, the bacteria, Cyanophyceæ, and the yeast fungi. In the yeast plant there is a large homogeneous spherical body which gives the reactions of chromatin similar to the chromatin of true nuclei. With this is associated a

prominent vacuole which contains a more or less amorphous substance of a chromatin nature. The two appear to be very closely related and undergo division simultaneously. From a study of the reactions of these two structures and their behaviour during division and in the formation of spores I suggested some years ago that the two together represent the nucleus of the higher plants, and therefore might be regarded as the nuclear apparatus. Guilliermond shortly afterwards in an exhaustive memoir tried to show that the homogeneous body described by me was a true nucleus with a normal nuclear structure, and that the nuclear vacuole, as I called it, must be simply an ordinary vacuole containing, however, a deeply stainable substance which he calls meta-chromatin. It is true that in most cases observed by him the nuclear body was perfectly homogeneous, but he accounted for this by stating that the fixing and staining had been imperfect. I have recently investigated a large number of different varieties of yeast with the result that my views as to the structure of the nuclear apparatus have been confirmed and the importance of the nuclear vacuole emphasised. In one case of a yeast which had been placed for some time in a sugar solution I discovered a structure in the nuclear body of the nature of a vacuolation which might be easily mistaken at a superficial glance as a normal nuclear structure. This structure or vacuolation, however, is closely connected no doubt with modifications in the activity of the cell due to a different nutrition, and may be concerned with the changes leading to spore formation in which, as I previously showed, the nuclear apparatus becomes modified, the vacuole disappearing and the nuclear body becoming more granular. I have, in fact, been able to obtain a complete series of stages showing the progressive modifications in the nuclear body leading to this condition, and am pretty clear that it is due to a process of vacuolation in the homogeneous body. I cannot agree with Guilliermond, therefore, in his interpretation of these structures, although I do not doubt that the nuclear vacuole is nutritive in function, and I do not object to his view that its contents are to be described as meta-chromatin. I am at the same time disposed to think that the homogeneous granule, which I have called the nuclear body, may be the actual representative of the nucleus, the vacuole being looked upon as merely serving a nutritive function for the nucleus. In that case we have a very simple nucleus indeed, but one which is of importance in helping us to arrive at conclusions concerning the nature of the nucleus in the bacteria and Cyanophyceæ.

The Cell Structure of the Cyanophyceæ.

It is easy to demonstrate in the living cell of the Cyanophyceæ that the contents are differentiated into two distinct regions: (1) an outer layer containing the colouring matter; and (2) a central colourless portion which is known as the central body. The central body is considered by many investigators to be a true nucleus. It contains a deeply staining granular substance which to some extent resists the action of digestive fluids, and is therefore similar to the chromatin in the nuclei of the higher plants. In 1887 Scott was able to demonstrate a reticulate structure in this body, and also saw some indications during its division of a process akin to karyokinesis. Zacharias also in the same year, largely on microchemical grounds, concluded that it was a nucleus. The problem has been the subject of investigation by numerous observers since that date with very varying results. These results may be shortly summarised as follows: The central body is not a nucleus (Macallum, Fischer, Massart, Chodat). It is a nucleus of a simple or rudimentary type (Hieronymus, Nadson, Butschli). It is a true nucleus similar to that found in the higher plants, and forms both chromosomes and spindle (Hegler, Kohl, Olive, Phillips).

The facts of the structure of this body, so far as I have been able to ascertain them by the examination of the cell both in the living and fixed conditions, are that it possesses a vacuolate structure, associated with granules which stain deeply in nuclear stains, resist the action of digestive fluids, give a strong reaction for phosphorus and masked iron, and, further, according to the recent researches of

Macallum, do not contain potassium. These qualities are characteristic of nuclein, and there can be, I think, no reasonable doubt that these granules are comparable to the chromatin of a true nucleus.

In favourable objects it can be seen that these chromatin granules are associated in rows, and are sometimes so close together as to give the impression of granular threads, united in such a way as to form a granular network.

During the division of the cell the central body becomes elongated, and this granular network in consequence becomes pulled out in such a way as to give the appearance of a number of threads lying side by side, and, as Olive has justly pointed out, this gives the impression in deeply stained cells of a number of separate chromosomes lying side by side. It does, in fact, resemble, at a superficial glance, a stage in the karyokinetic division of a nucleus. Careful examination, however, reveals the original reticulate structure, and the subsequent stages of division show that this central body divides by constriction only, and presents none of the characteristics of a true mitosis; and, contrary to the views of Kohl and Olive, nothing in the nature of a true spindle figure is formed.

In addition to the true chromatin granules there are present at the periphery of the central body, and in close contact, therefore, with the chlorophyll-containing portion of the cell, other granules of a different, more refractive appearance, the true nature of which is not known. These are the red granules of Butschli; and from the fact that they give similar reactions towards reagents as the chromatin were regarded by him as the true chromatin granules. Their true function is unknown, and they do not occur in all cells even of the same filament.

There can be no doubt that the interpretation of the structures we are here dealing with is very difficult, but I do not understand how the conclusions reached by Fischer in his most recent paper, Die Zelle der Cyanophyceæ, 'Bot. Zeit.,' 1905, can have been arrived at. If I interpret his conclusions correctly, he considers that the chromosome-like granules in the central body of *Oscillaria princeps* and *O. limosa* are composed of glycogen. In most other species glycogen is only found in the chromatophore, but the glycogen may pass from the chromatophore into the central body and become changed into another carbohydrate, which he calls 'anabænin.' This substance arranges itself either in the form of granules or of pseudo-mitotic skeins and similar masses. The nuclear-like figures which have been described by various observers are composed of anabænin, and this substance in cell division undergoes a pseudo-mitotic division or 'carbohydrate mitosis.'

It is, perhaps, a sufficient criticism of these conclusions to point out that the micro-chemical characteristics of these central granules are certainly not those of carbohydrates.

From a consideration of the facts we at present know concerning the central body we cannot, I think, escape the conclusion that it is of the nature of a nucleus, but one of a simple or rudimentary type. It is not sharply delimited from the surrounding cytoplasm, although it sometimes appears as a vacuolar cavity in the centre of the cell, with a vacuolar membrane around it. It seems to me that we might very well regard it simply as a specialised region of the cytoplasm which possesses a pronounced vacuolation associated with granules of chromatin or with a chromatin network.

The Function of the Nucleus of the Cyanophyceæ.

The nucleus of the Cyanophyceæ is very large, much larger proportionally than the nuclei of the higher algæ. It gives also a proportionally stronger reaction for phosphorus. Some observers have considered the large size and prominence of the central body as an argument against its nuclear nature. In the algæ the nuclei are much smaller in proportion to the cell, and in many forms are very difficult to make out. On the other hand the pyrenoids which are present in the cells of algæ stain more deeply in the nuclear stains, and give a much stronger reaction for phosphorus than the nuclei. In *Prassiola parietina* the pyrenoid is in the centre of the cell, and both in the living condition and in stained preparations is much more prominent than the slightly stained nucleus on one side of it. So, also,

in Zygnema there are two star-shaped chromatophores, each with a large pyrenoid in the middle, and between them a small very inconspicuous nucleus.

In the Cyanophyceæ we are struck at once with the extraordinary prominence of the central body and the complete absence of pyrenoids. It seems to me that possibly this may be correlated with the presence of the assimilative colouring matters in the cell, and that in the absence of a differentiated pyrenoid the central body combines both the nuclear and the pyrenoid function. It is a perfectly well-known fact that the pyrenoid exhibits many of the characteristics of nuclein. It is not impossible, therefore, that it may be a derivative of the nucleus or of a body which may have been the precursor of the nucleus in the cells of primitive plants. There are many facts which indicate that the Cyanophyceæ is not only a well-marked group, but one which is very rudimentary and possibly a very ancient group. It is, therefore, just in such a group that we should expect to find a less highly differentiated protoplast than we have in the algæ. We know that this is so as regards the chlorophyll-containing part of the cell, in that it contains no clearly differentiated chloroplast, and it may be that the central body itself is an undifferentiated region of the cell which includes both the function of a pyrenoid as well as that of a nucleus. This would explain its large size and chromatin characteristics, and also the absence of a differentiated pyrenoid and true nucleus such as we have in the higher algæ. It is true that there is no pyrenoid in those cells of the higher plants which contain chlorophyll, whilst the nucleus remains small proportionally to the size of the cell. In these plants, however, the chlorophyll corpuscles themselves give the phosphorus reaction.

The hypothesis here put forward receives considerable support if we compare the cells of the Cyanophyceæ with those of various bacteria. In colourless forms, such as *Beggiatoa alba*, various Spirilla, Bacilli, &c., we find very few chromatin granules; but in the coloured forms, in which there is a process of assimilation comparable probably to that in chlorophyll-containing cells, we find, as both Butschli and Fischer have shown, that the chromatin granules are much more abundant. They are not in the form of a definite central body, but they occur more abundantly in the centre of the cell than at the periphery.

My view, then, is that the large size of the central body in the Cyanophyceæ may be connected with the development of the chlorophyll assimilation; that it may be held to function both as a pyrenoid as well as a nucleus, and that this receives support from what is observed in the coloured bacteria, in which the cytoplasm contains a more abundant supply of chromatin granules than do the colourless bacteria.

Structure of the Bacterial Cell.

Owing to the small size of the bacterial cells it is very difficult to arrive at a correct interpretation of the structures observed. The examination of the larger forms, such as the various species of *Beggiatoa, Chromatium, Bacillus anthracis, Bacillus subtilis,* &c., have, however, revealed a certain differentiation, which enables us to come to some conclusions as to their actual structure. Ernst has shown that the contents of these cells are not homogeneous, as was formerly thought to be the case, but show a differentiation into a less stainable substance, and embedded in it one or more deeply stained granules.

Butschli has shown that the central portion of the contents of the cell exhibit a foam structure in which granules of a chromatin nature are embedded: this is surrounded by a thin layer of a less deeply stained substance, which sometimes accumulates more prominently at the ends of the cell. The central, more deeply stained, froth-like structure with its granules is the nucleus; the delicate peripheral layer is the cytoplasm. From a recent examination which I have made of *Beggiatoa alba, Beggiatoa roseo-persicina, Bacillus subtilis,* and other smaller species, I cannot agree with Butschli that there is a differentiation into a central body or nucleus, and peripheral cytoplasm. In the various species of *Beggiatoa* and *Spirilla* which I have examined the cell contents exhibit a reticulate or foam structure of the cytoplasm in which one or more deeply stained granules

may be embedded. As these granules stain deeply in nuclear stains, and also give a reaction for phosphorus, they are probably similar to chromatin. They are distributed throughout the whole cell, and are not specially confined to one place.

The variation in size and number of the chromatin granules in the different species examined is very considerable. In the colourless *Beggiatoa alba* and in various *Spirilla* there are very few small granules. In some cells of *Beggiatoa alba* they appear to be absent altogether. In these cells there is, therefore, no constituent of the cell which gives a pronounced reaction for chromatin. The cytoplasmic network gives a very slight reaction for phosphorus, but this is so slight as to be of little value.

In *Bacillus subtilis* there is one prominent granule, sometimes two, in each cell, and the same is true for *B. anthracis* according to Fischer, and for other forms of bacilli which I have observed. The structure of these bacilli is, in fact, very much like that of the yeast plant, except for the absence of the very prominent vacuole, of which, however, there is even here some evidence.

The coloured bacteria, on the other hand, appear to contain an abundance of granules. In *Beggiatoa roseo-persicina*, the cytoplasm of which is coloured pale red, the granules are very prominent in the middle of the cell, and Fischer figures the same for *Chromatium okenii.* These granules stain deeply in hæmatoxylin, and give a fairly strong reaction for phosphorus. But there is no clear demarcation into a central body and peripheral coloured cytoplasm, as occurs in the Cyanophyceæ.

We must conclude, therefore, that the bacteria do not contain anything which can be individualised as a nucleus, but that the nuclein constituent of the cell when present is contained in granules distributed throughout the cytoplasm.

Beggiatoa, and possibly other and more lowly forms, has under certain conditions apparently no chromatin granules at all. The cell contents give a slight reaction for phosphorus, if at all, and no deeper-stained granules can be clearly made out; the same result is obtained with methylene blue, and also with hæmatoxylin Under other conditions we find forms in which a few chromatin granules can be seen scattered about the cell, not in any special part of it nor in a central body. Hinze finds in a large form a considerable number of small granules. The cytoplasm exhibits a foam structure very beautifully in some cases, but this appears to be mainly—I think not entirely—due to the spaces left by the sulphur granules. In some specimens with only a few such granules the comparatively thick strands of cytoplasm between the granules did not show any foam structure at all.

The Evolution of the Nucleus.

All plant nuclei, from the algæ and fungi upwards, present a striking similarity both in structure and mode of division. The same appears to be true of the animal kingdom, from the protozoa upwards. But among the protozoa on the animal side, and the yeast fungi, bacteria, and Cyanophyceæ on the plant side, there is a kind of border kingdom in which occur structures which appear to represent the nuclei of the higher organisms, but are so different from them in many respects that it is very difficult to say whether they should be regarded as nuclei or not. As we have already seen, the central body of the Cyanophyceæ and the chromatin granules of the yeast plant and bacteria may represent simple or rudimentary forms of nuclei. It is, therefore, possible that we may obtain from them a clue or indication of some kind as to the origin of the nucleus and the process of its evolution.

It is among the protozoa that we find the greatest variation both in form and structure of these rudimentary nuclei. All the various parts of the nuclei of the higher animals can be recognised in them, but, as Calkins points out, are rarely present in one and the same nucleus. From a consideration of the various types Calkins considers that the most primitive nucleus is probably a single mass of chromatin without membrane or reticulum. By the division of this into granules,

their association into lines forming primitive chromosomes, the development of a linin network, and the formation of a definite nuclear membrane was gradually brought about the development of the typical nucleus.

In the three groups of plants the Cyanophyceæ, bacteria, and yeast fungi it is not possible to recognise all the various parts of typical nuclei as in the protozoa. In none of them do we find a nuclear membrane, nucleolus, chromosomes, or spindle figure, or centrosome. We have nothing very tangible, therefore, to compare with the typical nucleus of the higher plants, and it is no doubt very largely due to this that we have so many contradictory accounts of the nuclear structures in these forms.

At the same time the nuclei of the higher plants pass through stages in their division which more nearly approach in their structure the simple forms with which we are now concerned. Thus the nuclear membrane and nucleolus disappear, and the chromatin network becomes condensed into a number of homogeneous rods or granules, the chromosomes, which lie free in the cytoplasm. There seems to be no reason why we should not consider the simpler chromatin structures in the lower plants in the light of these ontogenetic changes, as we may term them, of typical nuclei, in order to obtain some indication of the origin and phylogenetic development of the nucleus.

We may take the colourless Beggiatoa as a starting-point; not that this form is the lowest, but because its structure is, on account of its size, more easily examined, and because it is connected possibly with the Cyanophyceæ on the one hand and with the ordinary bacteria on the other. From a careful examination and comparison of its structure with that of other low forms we obtain the following diagram, showing their possible relationships as indicated by their cytological structure:—

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Beggiatoa alba.

(Chromatin granules may or may not be present.)

Beggiatoa roseo-persicina, Chromatium okenii, &c.

Many chromatin granules often condensed in the centre of the cell. Cytoplasm coloured.

Cyanophyceæ.

Central body with chromatin granules surrounded by a peripheral coloured protoplasm).

?

Algæ.

Larger Spirilla with colourless cytoplasm. (Few small chromatin granules.)

Forms like *Cholera vibrio, B. lineola, B. anthracis, Typhus bacillus,* &c. Colourless. (One or two chromatin granules.)

Yeast Fungi.

With one or two chromatin granules associated with a nutritive vacuole.

?

Fungi.

In the simplest case the cell of Beggiatoa contains only cytoplasm without, so far as I can see by careful examination with the highest powers available, any differentiation of chromatin grains or structures of a like nature. Neither do I think that we can regard the protoplast as representing a nucleus. As Fischer points out, the idea that the protoplast of the bacteria stains like a nucleus is not correct, and, as I have been able to show, it certainly does not give a phosphorus reaction like a nucleus. It is, in fact, a simple undifferentiated mass of cytoplasm, either homogeneous or at times exhibiting a foam structure. In this cytoplasm a few granules of chromatin may become differentiated, and this is the first indication of the separation of nuclear substance. Whether there are any species of Beggiatoa or other bacteria which are permanently without nuclear granules I do not know, and it will be very difficult to prove it; but the fact that under certain conditions these cells exist without them seems to point to the conclusion that this may be the primary cell structure, as has been surmised by Haeckel and others.

At an early stage in the evolutionary history of the protoplasm, before a typical nucleus was evolved, we appear to have had the development of colouring matter for the function of assimilation, and a bifurcation into the two distinct lines of descent of the fungi and the algæ. This appears to have been accompanied by two distinct lines of nuclear evolution leading respectively to the development of the central body of the Cyanophyceæ and the nuclear apparatus of the yeast plant. The possible lines of development of the nucleus up to the yeast fungi on the one side and to the Cyanophyceæ on the other are clearly indicated in the diagram; but between the yeast fungi and the true fungi, and between the Cyanophyceæ and the algæ, there are gaps which we cannot bridge at present. It is possible that the evolution of the typical nucleus may have been brought about in the fungi by the more definite association of the nuclear vacuole with the homogeneous nuclear body, possibly acccompanied by a vacuolation of the latter, or that the nuclear body itself may have become the nucleus direct by a process of vacuolation and differentiation within itself.

In the case of the Cyanophyceæ I have already shown that the central body is a vacuolar structure associated with granules of chromatin, and that sometimes this vacuolation becomes so pronounced in resting cells that we get an appearance as of a limiting membrane between it and the cytoplasm. The granules run together and become associated in such a way as to simulate the spireme thread of an ordinary nucleus. Further, we have in some Cyanophyceæ a differentiation of a nuclein-like substance in the form of the red granules of Butschli at the periphery of the central body, which may be an early stage in the separation of a portion of its substance to perform the special functions of the pyrenoid. The complete separation of this into a definite pyrenoid and the formation around the remainder of a nuclear membrane would give us a differentiation comparable to some extent to what we find in *Euglena viridis*, where we have a reticulate nucleus which divides by a rudimentary process of karyokinesis, in which, so far as we know, there is no definite formation of chromosomes and no longitudinal splitting.

As to when or how the higher differentiation of the nucleus, with its chromosomes, longitudinal division, and spindle figure, arose we do not know. Possibly a careful investigation of the lower forms of the fungi and algæ and such organisms as Euglena, and especially the protozoa, may throw light upon this difficult problem.

CAPE TOWN.

WEDNESDAY, AUGUST 16.

The following Papers were read:—

1. *On the more Recent Advances in our Knowledge of Seaweeds.* *By* Professor R. W. PHILLIPS, *M.A.*, *D.Sc.*

Marine plant-life may be distinguished as attached shore vegetation or floating oceanic vegetation.

I. *Shore Vegetation.*—With rare exceptions this consists of *Algæ*:—blue-green, green, red, and olive-brown. Gaps still exist in our knowledge of the reproduction of some members in the green group, especially *Siphonaceæ*. Oltmanns has revised our view of the act of fertilisation in the red seaweeds. In the brown group, which constitute the great bulk of shore vegetation, the most interesting advance comes from Williams's discovery of the existence of motile antherozoids in *Dictyotaceæ*. His subsequent study of the cytology of plants of this family points to the existence of a sharp alternation of generations. The point at which reduction of the chromosomes takes place in *Fucaceæ* had been previously established by Farmer and Williams. There is still lacking successful cultivation of seaweeds 'from spore to spore.' The early stages of germination have been observed in some *Phæozoosporeæ*, and exhibit points of interest.

II. *Oceanic Vegetation.*—In our knowledge of the floating vegetation of the open sea great advance was made by the members of the German Plankton Expedition, and later by other observers. It is enormous in aggregate amount, although consisting of microscopic forms taken only by the tow-net. It exists for the most part in the superficial 50 fathoms; below 700 fathoms is probably continuous darkness, where no chlorophyll-containing organisms can survive. The adaptations in oceanic plankton to prevent rapid sinking are remarkable. It consists chiefly of *Diatomaceæ* and *Peridiniaceæ*. Coccospheres, Rhabdospheres, *Halosphæra*, and *Pyrocystis* are also interesting forms. Upon this oceanic vegetation, rather than the shore vegetation, it would seem that marine animal life—large and small—must ultimately depend for sustenance.

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2. *The Prothallium of* Gleichenia pectinata. *By* Professor D. H. CAMPBELL.

The prothallium and the reproductive organs (especially the antheridium) of this species show a near approach to those of *Osmunda*.

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3. *On the Healing of Parenchymatous Tissues in Plants.* *By* Professor M. C. POTTER, *M.A.*, *F.L.S.*

With regard to the healing of woody tissues when exposed by a cut or other wound, Temme has shown that the cavities of the xylem vessels especially, and of the other elements of the wood, are closed by a substance which he termed *wound-gum*. By the development of this wound-gum, which usually takes place within twenty-four to forty-eight hours from the time of injury, any loss of water at the wound, which might interfere with the transpiration current, is checked or completely stopped in a very short time; and, further, the interchange between the atmospheric gases and those in the intercellular spaces is restored to the special organs for this purpose, *e.g.*, stomata or lenticels. The presence of wound-gum increases the specific gravity of the exposed xylem (wound-wood) and causes it to assume the colour and texture of the duramen; hence Temme considers the wound-wood and duramen to be identical.

The formation of callus by exposed parenchymatous cells is well known, and

Shattock has shown how these cells, when injured by a sharp scalpel, are destroyed, and in the healed tissue are replaced by others derived from the division of adjacent cells.

Richards demonstrated the rise of temperature, and also the increased respiratory activity of wounded parenchymatous cells.

Nemec has traced the protoplasmic changes in cells adjacent to a wound.

In the case of parenchymatous tissues little attention has been paid to the manner in which the intercellular spaces are closed. Thus, for example, when a hyacinth or other leaf is cut, the rate of exchange between the intercellular and atmospheric gases is profoundly altered, and the first step towards healing such a wound is to seal the openings of the intercellular spaces and restore the rate of gaseous exchange to the normal condition. This sealing is accomplished by the formation of a substance probably derived from the cellulose wall; it is found fully developed in about twenty-four hours from the time of injury, and thus a cicatrix is made, which completely prevents the loss of aqueous vapour and of the entrance or escape of gases at the wounded surface. This substance is probably identical with wound-gum; it reacts to phloroglucin and other stains for lignin, and like it is not developed in an atmosphere deprived of free oxygen, such as in CO_2. The formation of wound-gum may thus in some way be connected with the rise of temperature discovered by Richards.

In addition to the hyacinth leaf, very beautiful preparations of wound-gum—showing the characteristic red of the lignin reaction with phloroglucin—can be observed in the leaf of *Agapanthus*, the epicotyl of *Avena*, the cortex of young woody stems, and in the reservoirs of reserve material, such as the swede or turnip. In fact, wound-gum appears to be generally developed as a consequence of mechanical injury.

The first step, then, towards the healing of both woody and parenchymatous tissue is the closing of the intercellular spaces by a cicatrix prior to the development of bark.

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4. *Joint Discussion with Section L on Educational Methods in the Teaching of Botany. Opened by* HAROLD WAGER, *F.R.S.*

THURSDAY, AUGUST 17.

The following Papers were read:—

1. *On the Vegetation and the Floral Elements of Tropical Africa. By* Professor A. ENGLER.

Professor Engler gave first a brief account of the meteorological conditions in Africa, especially of the differences of rainfall in East, West, and Central Africa, and then enumerated the 'formations of vegetation,' which are especially dependent upon the water and the temperature which they receive in the various seasons of the year, and also upon the chemical and physical conditions of the soil. One can distinguish almost the same formations in every large continental tropical country which ascends from the sea to high mountains, although the floral elements, or the components of the flora, are more or less different in tropical Africa, in tropical Asia, and in tropical America.

One can first separate the *halophilous littoral formations* from the others, because many littoral plants of East Africa are the same as those of East India, and because many of West Africa are the same as those of tropical America.

Then we have the *hydrophilous formations*, those which are especially favoured by moving or stagnant water, either the whole year, or only for some months or weeks. One finds a great variety of hydrophilous formations, and they are very luxuriant in those parts of Africa where there is much rainfall, and where water does not only come to the roots, but also from the clouds to the leaves. Those are

the *hydrophilous and hygrophilous formations*, which we find especially in equatorial Western Africa and eastwards to the Bahr-el-Ghasal.

After the hydrophilous formations we come to the *hygrophilous*, those whose vegetation is directly influenced by the atmospheric water. These formations are also very varied; thus we have those of the lower regions, which are megatherm, others of the middle regions, which are mesotherm, and others of the higher, cloudy regions, which are microtherm.

There are also many formations which one can name *subxerophilous*, and which belong to regions with a short rainy season, or limited deposit of mist; they are very numerous in the plains as well as in the mountains.

Finally we come to the true *xerophilous formations*, which receive very little rain, and that during only a short period of the year, or only dew at night-time. These formations are botanically of the greatest interest, because they show the most singular adaptations to the dry climate, which are well known to all botanists, who know some of the plants of the Karroo, of Namaqua- and Damaraland, of the dry East African steppes at the northern foot of the Usambara mountains, in Somaliland, and in the Sahara.

List of the principal Formations.

A. Halophilous Littoral Formations.—Mangrove—Littoral scrub—Herbaceous vegetation of sandy beech—Littoral rocks—Creeks.

B. Hydrophilous Formations.—Forest on alluvial soil or gallery-forest. *a* and *b*, hydrophilous and hygrophilous. (*a*) In very warm districts with abundant rainfall—(α) in West Africa; (β) in East Africa (*b*) In districts of medium warmth with abundant rainfall. (*c*) In districts very warm with a scarce rainfall. (*d*) In districts moderately warm with scarce rainfall.

Alluvial country without trees (*a*, *b*, *c*, *d*, as before).—Formation of the Podostemonaceæ in fast-running mountain streams and torrents—Formation of the lakes—Shallow pools—Pools with mixed plants—Marantaceæ (Clinogyne)-pools—Vossia-pools—Phragmites-pools—Papyrus-pools—Typhonodorum-pool (on the Isle of Zanzibar).

C. Hygrophilous Formations.—(*a*) *Megatherm*: Formation of the lowest evergreen rain-forest [(α) in West Africa; (β) in East Africa]. Middle evergreen rain-forest (varying in altitude from 400–1,300 m. above the sea, corresponding to the various altitudes of the mountains and ridges. [α, slopes; β, glades, clearings; γ, gullies.]—Upper evergreen rain-forest [α, slopes; β, glades; γ, gullies]. Less moist rain-forest on slopes exposed to dry winds. (*b*) *Mesotherm*: Moist pasture ground—Bamboo-forest of the mountains—Forest in the cloud region of the higher mountains.

D. Subxerophilous Formations.—Formation of the park-like woods in the coastal regions—Borassus groves—Hyphæne groves—Formation of the fertile submountainous region with red soil—Formation of the upper fertile submountainous region with black soil—Formation of the mixed mountainous forest on drier slopes—Formation of the mountain scrub—Mountain scrub with *Pteridium*—Mountain heath—Formation of *Pteridium* [(*a*) primary; (*b*) secondary]—Mountain scrub-steppe (steppe grass with shrubs)—Mountain tree-steppe—Rocky summits and slopes of the mountains—Stony slopes with humus—Formation of the shingle slips—Sunny flat rocks—Sunny rocky declivities—Dry mountain pasture-grounds—Upper dry mountain meadows—Upper dense scrub—Subalpine dwarf shrubs.

E. Xerophilous Formations —Saline 'steppe'—Steppe with various succulent plants—Steppe formation of the evergreen thorn shrubs and trees (Euphorbia)—Aloe-steppe (with numerous high Aloes)—Steppe of the deciduous-leaved spiny shrubs—Grassy 'orchard-steppe' (Obstgartensteppe, with scattered small spiny trees)—Mixed thorn- and shrub-steppe—Open grass-steppe—Grass-steppe with scattered trees.

While the *vegetation* is characterised by physiological types, the *flora* is characterised by the systematic position of the plants. There is no doubt that in

tropical Africa a floral element predominates, which is peculiar to this part of the world. An accurate comparison shows that this element is more nearly related to that of tropical Asia than to that of tropical America, and that it is especially nearly connected with that of India and Madagascar. But besides the tropical African element of the flora, we find in tropical Africa members of other elements—of the Madagassian, of the Indian, the South African, the boreal, the Mediterranean, and even of the tropical American. But it is to be noticed that these elements are distributed in the various formations in a very different way.

The different halophilous beach formations do not belong to the same floral element. On the coasts of East Africa there predominate, besides some plants truly African, members of the Indian and the Monsoon elements; whereas on the coasts of West Africa exists an element belonging to both tropical America and tropical Africa.

Besides, the accurate investigations of recent times have shown that in the hydrophilous and hygrophilous megatherm formations of Western Africa some genera exist, the other species of which are to be found only in the corresponding formations of tropical America. And not only some genera, but even whole families and tribes, are developed only in tropical America and in either West Africa or in the whole of tropical Africa; for instance, in the hygrophilous formations, the *Mayacaceæ*, *Rapateaceæ*, *Musaceæ-Strelitzioideæ*, *Balanophoraceæ-Langsdorffieæ*, *Moraceæ-Brosimeæ*, *Caricaceæ*, *Humiriaceæ*, *Winteranaceæ*, *Cactaceæ-Rhipsalideæ*, *Gentianaceæ-Leiphaimeæ*. In the subxerophilous and xerophilous formations of the plain regions and the inferior mountains some families and tribes behave in a similar manner, namely, the *Velloziaceæ*, *Hydnoraceæ*, *Turneraceæ*, *Loasaceæ*, *Rafflesiaceæ-Apodantheæ*, and *Cytineæ*. Besides these families there are to be mentioned some natural orders which have also members in the monsoon lands, but which are developed in rich numbers only in America and Africa; for instance, the *Pontederiaceæ*, the *Moraceæ-Dorstenieæ*, the *Rosaceæ-Chrysobalanoideæ*, the *Simarubaceæ-Simarubeæ*, the *Burseraceæ*, the *Dichapetalaceæ*, and the large genera *Hermannia* and *Asclepias*.

In the hygrophilous megatherm formations, and in the mesotherm formations of East Africa, especially in the rain forests and in the forests of the higher mountains, the Indian and Madagascar elements are rather numerous in members, and even the same species are to be found in the mountains of East Africa, the Madagassian Islands, and in India, especially many ferns.

The South African element, too, is not absent in these formations, but it is much more numerous in species in the shrub formations of Angola and East Africa. In the xerophilous formations the tropical African element is very nearly related to the Indian element, especially north of the equator.

Besides, in the subxerophilous and xerophilous formations of North-east Africa, and more in Somaliland than in Abyssinia, the Mediterranean element is represented by numerous genera; for instance, *Buxus*, *Pistacia*, *Farsetia*, *Diceratella*, *Malcolmia*, *Gypsophila*, *Micromeria*, *Lavandula*, *Carduncellus*, *Cistanche*, *Juniperus*, *Callitris*.

Finally, besides the Mediterranean, the boreal element has many species in the microtherm formations of the high mountains of Africa. These are relatively poor in plants originating from African types, whereas the boreal and Mediterranean forms which have immigrated into the higher mountains of Africa have developed in their new area new species and varieties.

At last it must be mentioned that, in spite of the narrow relations between the African mountain vegetation and the Mediterranean flora, there are wanting many genera and orders otherwise distributed over large areas; for instance, the *Abietineæ*, *Fagaceæ*, *Betulaceæ*, *Pirolaceæ*, *Ericaceæ-Rhododendroideæ*, *Aceraceæ*, *Caprifoliaceæ* (with exception of *Sambucus ebulus*), *Rosaceæ-Spiraeoideæ*, *Coriariaceæ*, *Daphne*, *Aconitum*, *Aquilegia*, *Draba*, *Euonymus*, *Geum*, *Ribes*, *Rhus*-Sect. *Trichocarpæ*, *Hieracium*, *Gentiana*, *Iris*, *Lilium*, *Fritillaria*, *Orchis*, *Ophrys*. The fact that of all these groups no members exist in the higher mountains of Africa proves that the boreal element has immigrated from the North and East into the Mediterranean regions, whereas, on the other hand, some types, now

believed to be properly African, for instance, *Encephalartos*, extended their area as far as Southern Europe. Therefore, the hypothesis cannot be maintained that in the Tertiary period the same mixed flora was distributed over all the Old World, a flora from which the various elements should have differentiated by-and-by.

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2. *The Phyto-Geographical Subdivisions of South Africa.* *By* R. Marloth, *Ph.D.*

[Plate IV.]

A. The Cape Province.

The bulk of its vegetation consists of evergreen shrubs with small leathery leaves, many of them belonging to endemic orders, sub-orders, genera and species of more or less South Temperate relationship. Among them are: Proteaceæ, Thymelæaceæ, Ericaceæ, Penæaceæ, Grubbiaceæ, Bruniaceæ, and Rutaceæ. Not less important are the Restionaceæ.

B. The Palæo-Tropical Province.

I. *The Grass-steppes.*

1. The basin of the Limpopo and Lower Vaal. The former is called the 'Bush Veld.'

This is closely related to, or really only a southern continuation of, the Central East African steppe and forest province. Numerous species of trees, especially from the orders Leguminosæ and Combretaceæ, together with *Faurea saligna*, tree Euphorbias (*E. Reinhardtii* (Volkens) Pax) and arborescent Aloes.

2. The Kalahari and Bushmanland.

Closely related to the Limpopo district, and practically differing only by the absence of open water and species dependent on a regular and not too scanty water supply. Acacias are specially numerous, and *A. Giraffæ* is present in most parts. As a whole it does not deserve the designation 'desert.'

3. The High Veld.

Altitude from 1,200 to 1,500 mètres. Wide stretches of grass lands without a tree or bush for miles. In the eastern parts the country is mountainous, and the vegetation consequently more varied.

4. The Kaffrarian countries.

Specially characterised by thorny scrub, with *Aloe ferox* on the hills and *Acacia horrida* along the rivers and in the plains. Succulents are common in many parts, especially species of *Cotyledon, Kalanchoe, Euphorbia, Aloe, Haworthia,* and *Gasteria.*

A special formation is represented by the mountain forests.

II. *The Central Districts of the Cape Colony.*

1. The Karroo.

This consists of the following parts:—

(*a*) The West Karroo, formed by the Bokkeveld and Tanqua Karroo.

(*b*) The Central Karroo, consisting of the Bastard, Mordenaar's, Great, and Eastern Karroo.

(*c*) The Little Karroo.

(*d*) The Robertson Karroo, south of the Langebergen. Abounds in succulents. Along the river-beds trees, especially *Acacia horrida* and *Rhus viminalis.*

2. The Karroid Plateau.

To this sub-province belong the Roggeveld, the Nieuwveld, and the wide plains to the north and east. Trees are entirely wanting, and more than 90 per cent. of the conspicuous vegetation consists of dwarf shrublets of Composites mixed with some succulents. Occasionally there are even patches of the latter or a larger proportion of them. Grass is occasionally thinly scattered.

3. Little Namaqualand.

This country is very varied in its vegetation, some parts of it belonging to the Karroo and others to the Karroid plains. The mountain-tops possess real Cape flora, and the coast strip is a desert.

As the boundaries of these regions have not been fully investigated as yet, I have not attempted to delineate them.

III. *The Western Littoral.*

A strip varying in width from a few miles in Little Namaqualand to thirty or fifty miles in Great Namaqualand and Damaraland.

A real desert. The most remarkable plant is *Welwitschia mirabilis.*

IV. *The Forests of the South Coast.*

The narrow coast strip between George and Humansdorp and the lower portion of the southern slopes of the Outeniqua and Zitzikamma mountains.

The most numerous trees are *Podocarpus elongata* and *Olea laurifolia*, which form about one-third of the forest.

The tall *Strelitzia alba*, several arborescent ferns (*Hemitelia capensis* and *Marattia fraxinifolia*), and a number of epiphytic orchids (*Angræcum* and *Mystacidium*) indicate the high rainfall.

V. *The South-Eastern Coast-belt.*

A narrow strip of low coast lands, reaching nearly as far as Algoa Bay. Characterised by *Phœnix reclinata*, the southernmost African palm, Cycadaceæ (*Encephalartos*), *Strelitzia* (three species), *Euphorbia grandidens*, and in the north mangroves.

NOTE.—This abstract and the accompanying map had to be completed before Dr. Bolus's new treatise on the flora of South Africa was available for reference.

FRIDAY, AUGUST 18.

The following Papers were read:—

1. *The Systematic Position of* Welwitschia. *By* Professor H. H. W. PEARSON, *M.A., F.L.S.*

The author gave an account of his investigations on the development and germination of the spores of *Welwitschia.* The material examined was collected in Damaraland in January 1904. Owing to the unsettled condition of the country the author was unable to stay long enough to obtain a complete series, and therefore the latest stages of germination of the spores and the process of fertilisation were not observed. The results established are sufficient to throw new light upon the relations of the genus to *Ephedra* and to *Gnetum,* and show that the views of some recent authors as to its position in the group Gnetaceæ must be considerably modified.

The South African Association for the Advancement of Science granted a sum of 25*l.* in aid of the research.

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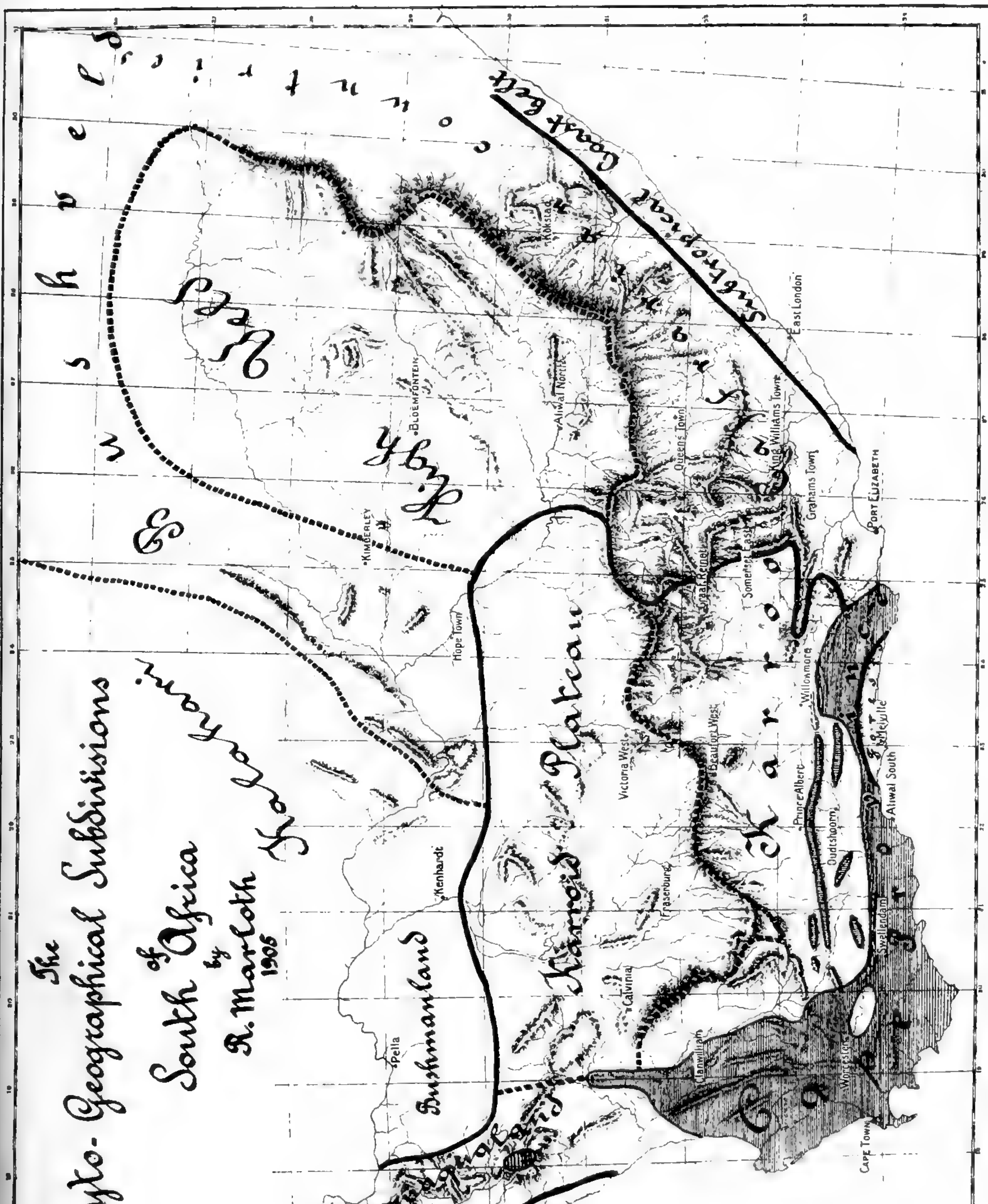
2. *Notes on Irrigation Farming on the Orange River. By* F. B. PARKINSON, *A.R.S.M., F.R.G.S.*

In the central portion of South Africa, say an area bounded north and south by Kimberley and Middelburg respectively, and east and west by Zastron and Prieska—there is an average rainfall of approximately 1 foot per annum, with a tendency to be less on the west and more on the east of this area. Usually about two-thirds of this rainfall occurs in the autumn months. Such rain as falls in


The Phyto-Geographical Subdivisions of South Africa by R. Marloth 1905
Western Littoral
Namaqualand
Bushmanland
Karroid Plateau
Kalahari
High Veld
Subtropical Coast belt
Port Nolloth
Pella
Kenhardt
Hope Town
Kimberley
Bloemfontein
Aliwal North
Kokstad
East London
King Williams Town
Queens Town
Grahams Town
Port Elizabeth
Somerset East
Graaff Reinet
Willowmore
Beaufort West
Victoria West
Prince Albert
Oudtshoorn
Aliwal South
Fraserburg
Calvinia
Clanwilliam
Worcester
Swellendam
Cape Town

summer (unless in showers of at least $\frac{3}{4}$ inch) may be harmful rather than beneficial, by inducing the germination of seeds, which are subsequently killed by drought.

With a rainfall such as this agriculture is not possible unless aided by artificially applied water. Although at present irrigation works on a large scale cannot be attempted, yet along the banks of the Orange River, which runs through the area mentioned above, there are pieces of good ground low enough to admit of profitable irrigation. At Baviaankrantz, where there is a sheet of alluvial soil some thousand acres in extent and 60 feet above the present bed of the river, an irrigation farm has been established. When in flood the Orange River at this point is 300 yards wide and 50 feet deep, while the quantity of silt brought down is so great that if ordinary pumps were employed their valves and pistons would soon be worn out. This difficulty is overcome by using chain-and-bucket pumps, working in shafts sunk at some distance from the river. The shafts are supplied with water by means of a 10-inch syphon, which connects them with a rocky pool well out of the main current of the river.

When raised, the water is distributed by means of 2-foot galvanised steel troughing, in which bungholes for drawing off the water are fitted every hundred yards.

The important winter crops are wheat, oats, and other cereals. These require altogether some four waterings, the total amount of water used varying with situation, season, &c., but a fair average for a cereal crop would be about seven hundred tons of water per acre.

Of summer crops, potatoes form the most important, but peas, beans, and many others are grown. These are planted in wet ground, but no more water is given till the plants are up, as otherwise a hard cake of soil is formed above them, through which the young plants cannot force their way.

Generally speaking, the great secret of success seems to lie in thoroughly breaking up the soil between each watering, and the crops are planted (except in the case of cereals, &c.) in such a way as to facilitate this.

JOHANNESBURG.

TUESDAY, AUGUST 29.

The President delivered his Address (see p. 562), after which the following Papers were read:—

1. *The Fossil Floras of South Africa. By* A. C. Seward, *M.A., F.R.S.*

The author gave a general account of the composition of the floras characteristic of the Lower Karroo, Stormberg, and Uitenhage series. He referred more especially to the desirability of searching for petrified specimens for the purpose of microscopical examination, and of obtaining fertile examples of many of the genera already described. The paper was read primarily for the purpose of drawing attention to gaps in our knowledge and to the chief desiderata from the point of view of those interested in the subject of palæo-botany.[1]

2. *Recent Information concerning South African Ferns and their Distribution. By* T. R. Sim.

[1] For a detailed account of Fossil Floras of South Africa and for a list of literature see *Annals of the South African Museum*, vol. iv. 1903.

WEDNESDAY, AUGUST 30.

The following Papers and Reports were read :—

1. *Botanical Photographs as Aids to Ecological Research. By* Professor F. E. WEISS, *D.Sc., F.L.S.*

The impetus given to the study of plant-associations by Warming's classical work on the ecological distribution of plants has been particularly noticeable in Great Britain, where quite a number of botanists have undertaken systematic surveys of the vegetation of various districts, and good progress has already been made in the botanical survey of Scotland and the North of England. There is no doubt, however, that the mapping of the vegetation of these regions, useful as it is, requires to be supplemented by a detailed study of the ecological factors governing the local distribution of plants, and this fact has not been lost sight of by those who have been engaged in the work. In this connection it is essential to obtain accurate records of the aspect and distribution of the vegetation at various altitudes, on different geological formations, and under varying conditions of drainage, illumination, moisture, &c. This can be done most efficiently by good photographs, and the recently established Committee for the survey and study of British vegetation, realising the necessity for such photographs, have decided to establish a collection of such ecological photographs in furtherance of their work. Some photographs of this nature are already included in the wider scheme for the collection and preservation of photographs of botanical interest established two years ago by the British Association, and it is to be hoped that the two collections will be made supplementary one to the other. The value of photography for work of this kind is undeniable. It has already been used with excellent results by Schimper in his 'Plant Geography,' and that such photographic representations of plants are coming into favour for teaching purposes is attested by the success of Karsten and Schenk's 'Vegetationsbilder,' and by the excellent photographic reproductions issued by Hansen as diagrams illustrating the geographical distribution of plants. The advance made by the use of such photographic reproductions for book- and class-illustration is evident on comparing the issues referred to with the illustrations of some of the older books dealing with kindred subjects. Not only does photography give the most truthful representation of plant form, but it can be made to show the aspect of the surroundings to which any plant, or group of plants, has become adapted. It shows the relative abundance or sparseness of the vegetation in any given locality, and gives a clear idea of the features of any plant-association, exhibiting the dominant form, or forms. Of course, all these points cannot, as a rule, be clearly shown on one photograph, and it becomes therefore necessary in most cases to have several views. It is more particularly desirable to have a detailed photograph of each member of a plant-association, as well as of the association as a whole.

Plant photography can, however, be usefully employed in the study of other subjects than geographical distribution. Photographs have already been in use for some time past for the representation of the results of plant-breeding where differences of form and habit are often very slight, and not easily represented by other than photographic means. Photographs are equally applicable to the representation of abnormal growths, whether pathological or teratological. On the Continent they have been used, too, in recording for different districts any trees of particular interest, either by reason of their great age or of any peculiarities of growth. This kind of work, due to the initiative of Dr. Conwentz, has resulted in some very beautiful publications by various Governments and public authorities, and their example might well be followed by local authorities and field clubs in Great Britain.

Even for cryptogamic work photography has proved of great use, especially in such groups as the lichens, in which the species exhibit a great variety of habit. But in other groups, such as algæ and liverworts particularly, considerable improvement may be made in the representations commonly found in botanical books.

There is a considerable field still for the scientific photographer, and it is hoped that the Committee formed for the collection and registration of photographs will receive continued support. To the teacher and worker in Great Britain it will be of particular help to know what photographs of colonial plants and plant-associations are extant, and from whom copies can be obtained. Knowledge of this kind the Committee is anxious to obtain and to circulate.

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2. *Report on the Registration of Botanical Photographs.*
See Reports, p. 226.

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3. *The Climate and Life-Zones of the Transvaal.*
By JOSEPH BURTT-DAVY, *F.L.S., F.R.G.S., F.R.Met.Soc.*

Though situated between 22° and 28° south latitude, the climate of at least four-fifths of the Transvaal is not tropical, owing to its high altitude. The mean annual temperature is about 56·3° F. at the highest altitudes, rising in the ratio of about *two* degrees per thousand feet of descent. The climate is characterised by extremes of temperature, hot days and cold nights, with sharp winter frosts (23° of frost has been registered). It is a region of periodic drought, which lasts for about six months; the dry and the cold seasons are concurrent, so that there is only one dormant season. The mean annual rainfall is about 28 inches, but as the spring rains begin late in the season, and are very intermittent in character, the growing season is too short for many tropical crops.

The main topographical features are a mountain range near the eastern border, only about 100 miles from the coast, rising to an altitude of about 8,000 feet, and a central plateau from 3,000 to 6,000 feet above sea-level.

The differences in altitude produce differences in climate and vegetation. These appear to fall naturally into three zones:—

1. The High Veld, ranging from 6,000 to 4,000 feet altitude.
2. The Middle Veld, „ „ 4,000 to 1,500 „ „
3. The Low Veld, „ „ 1,500 to 600 „ „

The Low Veld is a dry, tropical savannah region, well wooded, and free from frost, except occasionally along the river bottoms, which will produce crops the year round where the lack of winter rain can be replaced by irrigation. It produces the baobab, cassava, sugar-cane, cotton, tobacco, pearl millet, teosinte, avocado pear, custard apple, and, on the coast, the cocoanut. Hippopotami, crocodiles, lions, pythons, and maambas are characteristic animals. It is the home of the M'Sutu, Shagaan, and Zulu. It is an unhealthy region, owing to malarial and black-water fevers. East-coast tick-fever and horse-sickness cause serious loss among stock.

The High Veld is a treeless, grassy plateau, characterised by a short growing season, owing to late spring rains and early frosts in autumn, which prevent the cultivation of perennial tropical crops. Maize, Kaffir corn and potatoes, in summer; and wheat, barley and oats, in winter, under irrigation, are the staple crops; lucerne, sainfoin, and fescue grass do well; peaches are grown at every farmhouse; apples, pears, cherries, and grapes do well in certain localities. It is a healthy region for human beings and stock; malarial fever, horse-sickness, and East-coast tick-fever are almost unknown. Merino sheep do well in the eastern districts and Persian sheep and Angora goats in the western.

The Middle Veld is really intermediate between the other two zones. It is covered with acacia 'bush' and low trees, with intervening open grassy places. It is in the main a good cattle country, but is at present infected with East-coast tick-fever. Persian sheep and Kaffir goats thrive, but merinos do not do so well. Some malarial fever occurs in certain districts, but as a rule it is a healthy region. The rainfall is lower than on most of the High Veld. Sharp frosts occur in winter

along the streams and on the open flats, but the winter season is shorter than on the High Veld, and tobacco, citrus fruits, mangoes, pineapples and pawpaws, give excellent results in sheltered situations. Maize, pearl millet, and Kaffir corn are grown on the open flats. Sweet potatoes, pea-nuts, and castor beans do well.

The High Veld is subdivided into moisture belts. The greatest humidity is found in a narrow strip on the eastern slope of the Drakensberg, where the rainfall is from 55 to 40 inches, and damp mists occur even in winter. This belt is said to be 'humid all the year round,' and is known as the 'mist belt'; it produces filmy ferns, Hepaticæ, epiphytic ferns and orchids, and such evergreen trees as *Podocarpus*, *Xymalos*, and other species characteristic of the forests of the eastern districts of Cape Colony.

Passing either east or west of this 'mist belt' the rainfall rapidly diminishes; it is only 28 inches on the Portuguese frontier, at the Lebombo Range.

West of the Drakensberg there is a gradual diminution in rainfall passing towards the Kalahari Desert. This produces differences in natural vegetation and in crop-producing capacity, but owing to the general uniformity in topography it is at present difficult to delimit the belts.

East of an irregular line drawn somewhere in the neighbourhood of Witbank and Heidelberg the rainfall appears to range from 35 to 30 inches. This belt is generally spoken of as the 'Eastern Transvaal.'

From the western edge of this belt to a line drawn somewhere near Potchefstroom, or, roughly speaking, in the Witwatersrand and Pretoria districts, the mean rainfall is lower than that of the eastern belt, and probably ranges from 30 to 25 inches. This may be known as the 'Witwatersrand belt.'

West of Klerksdorp lies yet another belt, still drier in character, and with a markedly different flora; full data are not yet available, but the rainfall will probably be found to average from 25 to 15 inches. This belt appears to end at about the western border of the Transvaal, where it passes into the Kalahari region proper. It is generally spoken of as the 'South-western Transvaal.'

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4. *Bacteria as Agents in the Oxidation of Amorphous Carbon.* *By* Professor M. C. POTTER, *M.A.*, *F.L.S.*

According to present knowledge, amorphous carbon is only available as a source of plant food after its union with oxygen in the process of combustion. The author's investigations have proved that under the action of certain bacteria a slow oxidation of amorphous carbon takes place, CO_2 is evolved, and the carbon can be at once utilised for the nutrition of green plants. This leads to a consideration of the possibility that the vast supplies of carbon locked up in the world's coal-fields may be rendered available for plant life without the intervention of direct combustion.

Peculiar difficulties were experienced in dealing with the sterilisation of the carbon substances employed and the removal of CO_2, but after repeated experiments, and the adoption of special precautions for the elimination of possible sources of error, it has been demonstrated that charcoal undergoes slow oxidation under the action of a soil bacterium. This has been shown by passing a stream of air carefully deprived of all traces of CO_2 over the charcoal and through a Pettenkofer's tube containing baryta water, the presence of CO_2 being detected by titration against oxalic acid. The control experiments with charcoal under sterile conditions showed no evolution of CO_2. Commercial wood-charcoal is seldom sufficiently charred. Hence before being employed it was always subjected to a temperature of about 1200° in a metallurgical furnace. This treatment served to drive away all remaining volatile compounds and render the carbon amorphous; at the same time the entangled oxygen would be mainly converted into CO and the calcium salts into the oxide.

The oxidation has been confirmed by the detection of calcium carbonate in the charcoal exposed to the influence of the bacterium, and by the complete absence of this salt in the control flasks. A further confirmation is found in the fact that

charcoal exposed to the influence of the bacterium showed a rise of temperature above that of the control.

The results obtained from the charcoal were in complete accordance with a parallel series of experiments in which lampblack—treated for fourteen days with aqua regia—was used as the source of carbon.

In another set of experiments ordinary coal was subjected to the action of the same bacterium, and found to undergo oxidation.

Incidentally the inquiry throws some light upon the formation and decomposition of coal. It is clear that the ordinary process of decay, suspended through untold years, is resumed by the agency of bacteria or other saprophytic organisms when the necessary conditions of air, temperature and moisture are present.

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5. *Note on the Dissipation of Absorbed Solar Radiation by Xerophilous Plants.* *By* HORACE T. BROWN, *LL.D., F.R.S.*

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6. *Some Problems of Heredity.* *By* R. P. GREGORY, *M.A.*

In view of the results obtained by Darwin, Scott, Hildebrand, and others, it seemed likely that the characters of long and short style, well known in the Primulaceæ, might have a Mendelian inheritance. Experiments carried out by Mr. Bateson and the writer have shown that this is the case in *Primula Sinensis*, the short style being dominant, the long recessive. The inheritance is usually of the simplest Mendelian type. Some irregularities occurred, which, in view of the general trend of the evidence, we incline to regard as fortuitous. In addition to those cases, however, which can be so regarded, certain quite anomalous results occurred in the families raised from one individual short-styled plant. This plant and one of its offspring used as the ♂ parent produced 184 short-styled and only 3 long-styled plants. The same plants used as ♀ parents produced 34 short-styled and 32 long-styled plants.

In addition to the above experiments, an attempt was made to investigate certain possibilities respecting the consequences of legitimate and illegitimate unions. Darwin has shown that in *Primula* more seeds are set when plants with dissimilar styles are united (legitimately) than in illegitimate unions. In the latter case it became apparent that some egg-cells are capable of illegitimate fertilisation, while others are not. This fact suggested that there might be a differentiation among the ovules. To test this possibility we made a large number of trials, pollinating some flowers legitimately, some illegitimately, others with *both* kinds of pollen. We anticipated that, if differentiation exists, it would be revealed by the production of a maximum number of seeds by the flowers which had undergone double pollination.

This series of experiments has, however, led to no definite conclusion. They were carried on through two seasons, and a very large number of pollinations were made, both on *P. Sinensis* and *P. acaulis*, but the resulting figures are so discrepant that no answer can be given to the question proposed.

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7. *Infection Phenomena in various Uredineæ.* *By* I. B. POLE EVANS, *B.A., B.Sc.*

Infection by means of uredospores in the different species of *Puccinia* is of a very definite nature in each species.

It involves two distinct steps: (*a*) *inoculation*, which includes the swelling up of the tip of the germ tube over the external aperture of the stoma to form an appressorium, from which a narrow branch is given off, which passes down through the stoma and swells out into a definitely shaped vesicle, the *substomatal vesicle*; and (*b*) *infection*, which entails the growth out of this substomatal

vesicle of one or more infecting hyphæ, which at once form haustoria in the first cells with which they come into contact.

The substomatal vesicle is always of the same shape and character in the same species, but differs very strikingly in the different species, both in shape and character, so that it is possible to identify mycelia which resemble one another very closely by tracing them back to their infection vesicles.

The infection phenomena of *Puccinia glumarum*, *P. dispersa*, *P. Symphyti-Bromorum*, *P. Phlei pratensis*, *P. simplex* and *P. coronifera* were described in detail.

8. *On our Knowledge of South African Succulents.* *By* Dr. S. Schönland.

9. *Finger-and-Toe* (Plasmodiophora Brassicæ.) *By* George Potts, *B.Sc., Ph.D.*

This paper comprises part of the results of experiments conducted at Newcastle-on-Tyne and Halle-a.-d.-Saale between October 1899 and July 1902. The work was carried out under Professor Potter and Professor Klebs respectively, and to both the author wishes to express thanks for valuable guidance and many useful suggestions. He had originally intended to give a full account of the whole investigation, but considerations of time and space prevented this. He therefore had to confine himself to a few points, and in making the selection chose those which hinge on the action of calcium compounds in preventing the disease.

It is shown that the reaction of the soil has an enormous influence on the activity of the fungus. Thus acids, *e.g.*, sulphuric, phosphoric, and acetic, encourage it; while alkaline substances, *e.g.*, quicklime, sodium carbonate, and caustic potash, check it, and if sufficiently strong entirely prevent it. It is demonstrated that in alkalinity we have a means of preventing the disease, because the strength required to stop the active development of *Plasmodiophora Brassicæ* causes no perceptible injury to the plants.

The various modes of action which have been attributed to calcium compounds in sometimes preventing the disease are discussed in detail. By soil analyses and pot experiments it is shown that the soil calcium has not necessarily any relation to the disease. Further, any material manurial or poisoning influence is repudiated. Where calcium compounds are an influential preventive when applied a season or more before the crop is taken, it is shown that the action is very probably due to indirectly strengthening the plant by virtue of those well-known, but perhaps imperfectly understood, inter-related mechanical, chemical, and biological effects of the soil. On the other hand, when they are effective when applied about the time of sowing, their effect is due to the reaction produced. It is suggested that in practice the best results will probably be obtained by combining the medicinal and reaction effects.

10. *A Revised List of the Indigenous Plants of Natal.* *By* J. Medley Wood.

11. *Report on Experimental Studies in the Physiology of Heredity.*

See Reports, p. 226.

Section L.—EDUCATIONAL SCIENCE.

President of the Section—Sir Richard C. Jebb, O.M., Litt.D., D.C.L., M.P.

CAPE TOWN.

WEDNESDAY, AUGUST 16.

The President delivered the following Address:—

University Education and National Life.

Every country has educational problems of its own, intimately dependent on its social and economic conditions. The progressive study of education tends, indeed, towards a certain amount of general agreement on principles. But the crucial difficulties in framing and administering educational measures are very largely difficulties of detail; since an educational system, if it is to be workable, must be more or less accurately adjusted to all the complex circumstances of a given community. As one of those who are now visiting South Africa for the first time, I feel that what I bring with me from England is an interest in education, and some acquaintance with certain phases of it in the United Kingdom; but with regard to the inner nature of the educational questions which are now before this country, I am here to learn from those who can speak with knowledge. In this respect the British Association is doing for me very much what a famous bequest does for those young men whom it sends to Oxford; I am, in fact, a sort of Rhodes scholar from the other end—not subject, happily, to an age-limit—who will find here a delightful and instructive opportunity of enlarging his outlook on the world, and more particularly on the field of education.

As usage prescribes that the work of this Section, as of others, should be opened by an Address from the Chair, I have ventured to take a subject suggested by one of the most striking phenomena of our time—the growing importance of that part which Universities seem destined to play in the life of nations.

Among the developments of British intellectual life which marked the Victorian age, none was more remarkable, and none is more important to-day, than the rapid extension of a demand for University education, and the great increase in the number of institutions which supply it. In the year 1832 Oxford and Cambridge were the only Universities south of the Tweed, and their position was then far from satisfactory. Their range of studies was too narrow; their social operation was too limited. Then, by successive reforms, the quality of their teaching was improved, and its scope greatly enlarged; their doors were opened to classes of the community against which they had formerly been closed. But meanwhile the growing desire for higher education—a result of the gradual improvement in elementary and secondary training—was creating new institutions of various kinds. The earliest of these arose while access to Oxford and Cambridge was still restricted. The University of Durham was established in 1833.

In 1836 the University of London, as an examining and degree-giving body, received its first charter. A series of important Colleges, giving education of a University type, arose in the greater towns of England and Wales. The next step was the formation of federal Universities. The Victoria University, in which the Colleges of Manchester, Liverpool, and Leeds were associated, received its charter in 1880. The Colleges of Aberystwyth, Bangor, and Cardiff were federated in the University of Wales, which dates from 1893. The latest development has been the institution of the great urban Universities. The foundation of the University of Birmingham hastened an event which other causes had already prepared. The federal Victoria University has been replaced by three independent Universities, those of Manchester, Liverpool, and Leeds. Lastly, a charter has recently been granted to the University of Sheffield. Then the University of London has been reconstituted; it is no longer only an Examining Board; it is also a teaching University, comprising a number of recognised schools in and around London. Thus in England and Wales there are now no fewer than ten teaching Universities. Among the newer institutions there are some varieties of type. But, so far as the new Universities in great cities are concerned, it may be said that they are predominantly scientific, and also that they devote special attention to the needs of practical life, professional, industrial, and commercial; while at the same time they desire to maintain a high standard of general education. It may be observed that in some points these Universities have taken hints from the four ancient Universities of Scotland,—which themselves have lately undergone a process of temperate reform. The Scottish Universities are accessible to every class of the community; and the success with which they have helped to mould the intellectual life of a people traditionally zealous for education renders their example instructive for the younger institutions. With reference to the provision made by the newer Universities for studies bearing on practical life, it should be remarked that much has also been done in the same direction by the two older Universities. At Cambridge, for example, degrees can be taken in Economics and associated branches of Political Science; in Mechanism and Applied Mechanics; and in Agricultural Sciences. It certainly cannot now be said that the old Universities neglect studies which are of direct utility, though they rightly insist that the basis and method of such studies shall be liberal.

In looking back on the general course of this whole movement in England, we find that it has been steady, smooth, and fairly rapid. It has not been due to any spasmodic impulse or artificial propaganda, but has been the result of natural forces operating throughout the nation. Universities, and the training which they give, have come to count for more in our national life as a whole. It should be noted in passing that the missionary movement known as University Extension did not arise in the first instance from spontaneous academic action, but was a response to public appeals from without. It had its origin in memorials addressed to the University of Cambridge, in 1872, by various public bodies; and it was in compliance with those memorials that, in the winter of 1873, the first courses of Extension lectures were organised in the Midlands. Another fact of vital significance in the movement is that it has included ample provision for the higher education of women.

With reference to the present position and prospects of the higher education in South Africa, I tried, before leaving England, to acquaint myself with at least the outlines of the general situation; but it is only with great diffidence that I shall offer a few observations bearing on some of the broader aspects of the question. I trust to be heard with indulgence by those from whom I shall hope to learn more. At any rate, I can truly say that the question seems to me one of the deepest interest and of the gravest importance. Indeed, it does not require much insight or imagination to apprehend the greatness of the issues that are involved.

In the first place, it would be correct, if I am not mistaken, to say that in South Africa at large there is a genuine and a keen desire for efficient education of the highest type. A sound liberal education is desired for all who can profit by it, whatever their future callings are to be. But the practical and immediate

need for the organising of the highest teaching is felt, I believe, more particularly in regard to three great professions—the profession of Engineering in all its branches; the profession of Agriculture (including Forestry); and the profession of Education itself, on which the intellectual future of South Africa must so largely and directly depend. That the interest in the higher instruction is so real must be regarded as the best tribute to the efforts of those able and devoted men who, in various parts of this land, have laboured with dauntless perseverance for the improvement of primary and secondary education. Unstinted gratitude is due also to the University of the Cape of Good Hope. It is acknowledged on all hands that the University, as the chief guardian of learning in South Africa, has done admirable work in maintaining a high standard of general education. Certainly it cannot be regarded as any disparagement of that work if, as seems to be the case, a widespread desire exists that South Africa should possess an institution, or institutions, of University rank, which, besides examining, should also teach. That is a natural progress, which is illustrated by the recent reconstitution of the London University itself. I am not qualified, nor should I desire, to discuss the various difficulties of detail which surround the question of a teaching University. That question is, for South Africa, an eminently practical one; and doubtless it will be solved, possibly at no distant time, by those who are most competent to deal with it. I will only venture to say a few words on some of the more general aspects of the matter.

The primary needs of daily life in a new country make demands for certain forms of higher training—demands which may be unable to wait for the development of anything so complex and costly as a teaching University. It is necessary to provide a training for men who shall be able to supervise the building of houses, the making of roads, bridges, and railways, and to direct skilled labour in various useful arts and handicrafts. The first step in such a provision is to establish technical schools and institutes. Germany is, I suppose, the country where the educational possibilities of the technical school are realised in the amplest measure. In Germany the results of the highest education are systematically brought to bear on all the greater industries. But this highest education is not given only in completely equipped Universities which confer degrees. It is largely given in the institutions known as Technical High Schools. In these schools teaching of a University standard is given, by professors of University rank, in subjects such as Architecture, various branches of Engineering, Chemistry, and General Technical Science. There are, I think, some ten or eleven of these Technical High Schools in Germany. In these institutions the teaching of the special art or science, on its theoretical side, is carried, I believe, to a point as high as could be attained in a University; while on the practical side it is carried beyond the point which in a University would usually be possible. In England we have nothing, I believe, which properly corresponds to the German Technical High School; but we may expect to see some of the functions of such a school included among the functions of the new Universities in our great industrial and commercial towns.

Now Technical Schools or Institutes, which do not reach the level of a German Technical High School, may nevertheless be so planned as to be capable of being further developed as parts of a great teaching University. And the point which I now wish to note is this—that the higher education given in a Technical Institute which is only such, will not be quite the same as that given in the corresponding department of a teaching University. University education, as such, when it is efficient, has certain characteristics which differentiate it from the training of a specialist, however high the level of the teaching in the special subject may be. Here, however, I pause for a moment to guard against a possible misconception. I am not suggesting that the specialist training given in a technical institute though limited, is not an excellent thing in itself; or that, in certain conditions and circumstances, it is not desirable to have such a training, attested by a diploma or certificate, instead of aiming at a University standard and a University degree. Universities themselves recognise this fact. They reserve their degrees for those who have had a University training; but they also grant diplomas for proficiency in certain special branches of knowledge. Cambridge, for instance, gives a

diploma in the Science and Practice of Agriculture; and the examinations for the diploma are open to persons who are not members of the University.

But the University training, whatever its subject, ought to give something which the purely specialist training does not give. What do we understand by a University education? What are its distinctive characteristics? The word *Universitas*, as you know, is merely a general term for a corporation, specially applied in the Middle Ages to a body of persons associated for purposes of study, who, by becoming a corporation, acquired certain immunities and privileges. Though a particular University might be strongest in a particular faculty, as Bologna was in Law and Paris in Theology, yet it is a traditional attribute of such a body that several different branches of higher study shall be represented in it. It is among the distinctive advantages of a University that it brings together in one place students—by whom I mean teachers as well as learners—of various subjects. By doing this the University tends to produce a general breadth of intellectual interests and sympathies; it enables the specialist to acquire some sense of the relations between his own pursuit and other pursuits; he is helped to perceive the largeness of knowledge. But, besides bringing together students of various subjects, it is the business of a University to see that each subject shall be studied in such a manner as to afford some general discipline of the mental faculties. In his book on 'The Idea of a University' Newman says:—

'This process of training, by which the intellect, instead of being formed or sacrificed to some particular or accidental purpose, some specific trade or profession, or study or science, is disciplined for its own sake, for the perception of its own proper object, and for its own highest culture, is called Liberal Education; and though there is no one in whom it is carried as far as is conceivable, or whose intellect would be a pattern of what intellects should be made, yet there is scarcely anyone but may gain an idea of what real training is, and at least look towards it, and make its true scope and result, not something else, his standard of excellence; and numbers there are who may submit themselves to it and secure it to themselves in good measure. And to set forth the right standard, and to train according to it, and to help forward all students towards it according to their various capacities, this I conceive to be the business of a University.'

It may be granted that the function of a University, as Newman here describes it, is not always realised; Universities, like other human institutions, have their failures. But his words truly express the aim and tendency of the best University teaching. It belongs to the spirit of such teaching that it should nourish and sustain ideals; and a University can do nothing better for its sons than that; a vision of the ideal can guard monotony of work from becoming monotony of life. But there is yet another element of University training which must not be left out of account it is, indeed, among the most vital of all. I mean that informal education which young men give to each other. Many of us, probably, in looking back on our undergraduate days, could say that the society of our contemporaries was not the least powerful of the educational influences which we experienced. The social life of the Colleges at Oxford and Cambridge is a most essential part of the training received there. In considering the questions of the higher education in South Africa it is well to remember that the social intercourse of young students, under conditions such as a great residential University might provide, is an instrument of education which nothing else can replace. And it might be added that such social intercourse is also an excellent thing for the teachers.

The highest education, when it bears its proper fruit, gives not knowledge only, but mental culture. A man may be learned, and yet deficient in culture; that fact is implied by the word 'pedantry.' 'Culture,' said Huxley, 'certainly means something quite different from learning or technical skill. It implies the possession of an ideal, and the habit of critically estimating the value of things by a theoretic standard.' 'It is the love of knowledge,' says Henry Sidgwick, 'the ardour of scientific curiosity, driving us continually to absorb new facts and ideas, to make them our own, and fit them into the living and growing system of our thought; and the trained faculty of doing this, the alert and supple intelligence

exercised and continually developed in doing this—it is in these that culture essentially lies.' And if this is what culture really means, evidently it cannot be regarded as something superfine—as an intellectual luxury suited only for people who can lead lives of elegant leisure. Education consists in organising the resources of the human being; it seeks to give him powers which shall fit him for his social and physical world. One mark of an uneducated person is that he is embarrassed by any situation to which he is not accustomed. The educated person is able to deal with circumstances in which he has never been placed before; he is so, because he has acquired general conceptions; his imagination, his judgment, his powers of intelligent sympathy have been developed. The mental culture which includes such attributes is of inestimable value in the practical work of life, and especially in work of a pioneer kind. It is precisely in a country which presents new problems, where novel difficulties of all sorts have to be faced, where social and political questions assume complex forms for which experience furnishes no exact parallels, it is precisely there that the largest and best gifts which the higher education can confer are most urgently demanded.

But how is culture, as distinct from mere knowledge, to be attained? The question arises as soon as we turn from the machinery of the higher education to consider its essence and the general aims which it has in view. Culture cannot be secured by planning courses of study, nor can it be adequately tested by the most ingenious system of examinations. But it would be generally allowed that a University training, if it is really successful, ought to result in giving culture, over and above such knowledge as the student may acquire in his particular branch or branches of study. We all know what Matthew Arnold did, a generation ago, to interpret and diffuse in England his conception of culture. The charm, the humour, and also the earnestness of the essays in which he pleaded that cause render them permanently attractive in themselves, while at the same time they have the historical interest of marking a phase in the progress of English thought and feeling about education. For, indeed, whatever may be the criticisms to which Arnold's treatment of the subject is open in detail, he truly indicated a great national defect; and by leading a multitude of educated persons to realise it, he helped to prepare the way for better things. Dealing with England as it was in the sixties, he complained that the bulk of the well-to-do classes were devoid of mental culture—crude in their perceptions, insensible to beauty, and complacently impenetrable to ideas. If, during the last thirty or forty years, there has been a marked improvement, the popular influence of Matthew Arnold's writings may fairly be numbered among the contributory causes, though other and much more potent causes have also been at work. When we examine Arnold's own conception of culture, as expressed in successive essays, we find that it goes through a process of evolution. At first he means by 'culture' a knowledge and love of the best literature, ancient and modern, and the influence on mind and manners which flows thence. Then his conception of culture becomes enlarged; it is now no longer solely or mainly æsthetic, but also intellectual; it includes receptivity of new ideas; it is even the passion for 'seeing things as they really are.' But there is yet a further development. True culture, in his final view, is not only æsthetic and intellectual; it is also moral and spiritual; its aim is, in his phrase, 'the harmonious expansion of all the powers which make the beauty and worth of human nature.' But whether the scope which Arnold, at a particular moment, assigned to culture was narrower or wider, the instrument of culture with which he was chiefly concerned was always literature. Culture requires us, he said, to know ourselves and the world; and, as a means to this end, we must 'know the best that has been thought and said in the world.' By literature, then—as he once said in reply to Huxley—he did not mean merely *belles lettres*; he included the books which record the great results of science. But he insisted mainly on the best poetry and the highest eloquence. In comparing science and literature as general instruments of education, Arnold observed that the power of intellect and knowledge is not the only one that goes to the building-up of human life; there is also the power of conduct and the power of beauty. Literature, he said, serves to bring knowledge into relation with our

sense for conduct and our sense for beauty. The greater and more fruitful the progress of science, the greater is the need for humane letters to establish and maintain a harmony between the new knowledge and those profound, unchanging instincts of our nature.

It is not surprising that, in the last third of the nineteenth century, Arnold's fascinating advocacy of literature, as the paramount agency of culture, should have incurred some criticism from the standpoint of science and of philosophy. The general drift of this criticism was that the claim which he made for literature, though just in many respects, was carried too far; and also that his conception of intellectual culture was inadequate. As a representative of such criticism, I would take the eminent philosopher whose own definition of culture has already been cited, Henry Sidgwick: for no one, I think, could put more incisively the particular point with which we are here concerned. 'Matthew Arnold's method of seeking truth,' says Sidgwick, 'is a survival from a pre-scientific age. He is a man of letters pure and simple; and often seems quite serenely unconscious of the intellectual limitations of his type.' The critic proceeds to enumerate some things which, as he affirms, are 'quite alien to the habitual thought of a mere man of letters.' They are such as these: 'How the crude matter of common experience is reduced to the order and system which constitutes it an object of scientific knowledge; how the precisest possible conceptions are applied in the exact apprehension and analysis of facts, and how by facts thus established and analysed the conceptions in their turn are gradually rectified; how the laws of Nature are ascertained by the combined processes of induction and deduction, provisional assumption and careful verification; how a general hypothesis is used to guide inquiry, and, after due comparison with ascertained particulars, becomes an accepted theory; and how a theory, receiving further confirmation, takes its place finally as an organic part of a vast, living, ever-growing system of knowledge.' Sidgwick's conclusion is as follows: 'Intellectual culture, at the end of the nineteenth century, must include as its most essential element a scientific habit of mind; and a scientific habit of mind can only be acquired by the methodical study of some part at least of what the human race has come scientifically to know.'

There is nothing in that statement to which exception need be taken by the firmest believer in the value of literary education. The more serious and methodical studies of literature demand, in some measure, a scientific habit of mind, in the largest sense of that expression; such a habit is necessary, for instance, in the study of history, in the scientific study of language, and in the 'higher criticism.' Nor, again, does anyone question that the studies of the natural sciences are instruments of intellectual culture of the highest order. The powers of observation and of reasoning are thereby disciplined in manifold ways; and the scientific habit of mind so formed is in itself an education. To define and describe the modes in which that discipline operates on the mind is a task for the man of science; it could not, of course, be attempted by anyone whose own training has been wholly literary. But there is one fact which may be noted by any intelligent observer. Many of our most eminent teachers of science, and more especially of science in its technical applications, insist on a demand which, in the province of science, is analogous to a demand made in the province of literary study by those who wish such study to be a true instrument of culture. As the latter desire that literature should be a means of educating the student's intelligence and sympathies, so the teachers of science, whether pure or applied, insist on the necessity of cultivating the scientific imagination, of developing a power of initiative in the learner, and of drawing out his inventive faculties. They urge that, in the interests of the technical industries themselves, the great need is for a training which shall be more than technical—which shall be thoroughly scientific. Wherever scientific and technical education attains its highest forms in institutions of University rank, the aim is not merely to form skilled craftsmen, but to produce men who can contribute to the advance of their respective sciences and arts, men who can originate and invent. There is a vast world-competition in scientific progress, on which industrial and commercial progress must ultimately depend; and it is of national importance for every country that it should have men who are not merely

expert in things already known, but who can take their places in the forefront of the onward march.

But meanwhile the claims of literary culture, as part of the general higher education, must not be neglected or undervalued. It may be that, in the pre-scientific age, those claims were occasionally stated in a somewhat exaggerated or one-sided manner. But it remains as true as ever that literary studies form an indispensable element of a really liberal education. And the educational value of good literature is all the greater in our day, because the progress of knowledge more and more enforces early specialisation. Good literature tends to preserve the breadth and variety of intellectual interests. It also tends to cultivate the sympathies; it exerts a humanising influence by the clear and beautiful expression of noble thoughts and sentiments; by the contemplation of great actions and great characters; by following the varied development of human life, not only as an evolution governed by certain laws, but also as a drama full of interests which intimately concern us. Moreover, as has well been said, if literature be viewed as one of the fine arts, it is found to be the most altruistic of them all, since it can educate a sensibility for other forms of beauty besides its own. The genius of a Ruskin can quicken our feeling for masterpieces of architecture, sculpture, and painting. Even a very limited study of literature, if it be only of the right quality, may provide permanent springs of refreshment for those whose principal studies and occupations are other than literary. We may recall here some weighty words written by one of the very greatest of modern men of science. 'If I had to live my life again,' said Charles Darwin, 'I would have made it a rule to read some poetry and listen to some music at least once every week. . . . The loss of these tastes is a loss of happiness, and may possibly be injurious to the intellect, and more probably to the moral character, by enfeebling the emotional part of our nature.' The same lesson is enforced by John Stuart Mill, in that remarkable passage of his Autobiography where he describes how, while still a youth, he became aware of a serious defect, a great lacuna, in that severe intellectual training which, for him, had commenced in childhood. It was a training from which the influences of imaginative literature had been rigidly excluded. He turned to that literature for mental relief, and found what he wanted in the poetry of Wordsworth. 'I had now learned by experience'—this is his comment—'that the passive susceptibilities needed to be cultivated as well as the active capacities, and required to be nourished and enriched as well as guided.' Nor is it merely to the happiness and mental well-being of the individual that literature can minister. By rendering his intelligence more flexible, by deepening his humanity, by increasing his power of comprehending others, by fostering worthy ideals, it will add something to his capacity for co-operating with his fellows in every station of life and in every phase of action; it will make him a better citizen, and not only a more sympathetic but also a more efficient member of society.

One of the urgent problems of the higher education in our day is how to secure an adequate measure of literary culture to those students whose primary concern is with scientific and technical pursuits. Some of the younger English Universities, which give degrees in Science, contribute to this purpose by providing certain options in the Science curriculum; that is, a given number of scientific subjects being prescribed for study with a view to the degree of B.Sc., the candidate is allowed to substitute for one of these a subject taken from the Arts curriculum, such, for instance, as the Theory and Practice of Education. This is the case in the University of Wales and in the University of Birmingham; and there are indications, I believe, that this example will be followed elsewhere. Considering how hard and sustained is the work exacted from students of science, pure or applied, it seems important that the subjects from which they are to derive their literary culture should be presented to them, not in a dryasdust fashion, not chiefly as subjects of examination, but rather as sources of recreation and changes of mental activity. From this point of view, for British students of science the best literature of the English language offers unequalled advantages. It may be mentioned that the Board of Education in London is giving particular attention to

the place which English literature should hold in the examination of students at the Training Colleges, and has under consideration carefully planned courses of study, in which portions of the best English writers of prose and of verse are prescribed to be read in connection with corresponding periods of English history, it being understood that the study of the literature shall be directed, not to philological or grammatical detail, but to the substance and meaning of the books, and to the leading characteristics of each writer's style. If, on the other hand, the student is to derive his literary culture, wholly or in part, from a foreign literature, ancient or modern, then it will be most desirable that, before leaving school, he should have surmounted the initial difficulties of grammar, and should have learned to read the foreign language with tolerable ease.

When we look at this problem—how to combine the scientific and the literary elements of culture—in the light of existing or prospective conditions in South Africa, it appears natural to suppose that, in a teaching University, the Faculty of Education would be that with which literary studies would be more particularly connected. And if students of practical sciences, such as Engineering and Agriculture, were brought together at the same centre where the Faculty of Education had its seat, then it should not be difficult, without unduly trenching on the time demanded by scientific or technical studies, to provide such students with facilities for some measure of good literary training.

A further subject is necessarily suggested by that with which we have been dealing—I mean the relation of University to Secondary Education; but on that I can only touch very briefly. Before University Education can be widely efficient it is indispensable that Secondary Education should be fairly well developed and organised. Secondary Education should be intelligent—liberal in spirit—not too much trammelled by the somewhat mechanical uniformity apt to result from working for external examinations, but sufficiently elastic to allow for different aptitudes in the pupils, and to afford scope for the free initiative of able teachers. It is a gain for the continuity of education when a school-leaving examination can be accepted as giving admission to the University. Such an examination must be conducted under the authority of the University; but there is much to be said in favour of the view that, under proper safeguards, the school-teachers should have a part in the examination; always provided that the ultimate control, and the decision in all cases of doubt, shall rest with the University. A system of school-leaving examinations for this country was earnestly advocated, I believe, by Mr. P. A. Barnett, who has achieved such excellent work for the cause of education in Natal. To discuss the advantages or difficulties of such a proposal, as they at present affect South Africa, would demand knowledge which I do not possess; and I must content myself with the expression of a hope that in days to come—perhaps in a not distant future—it may be found practicable to form such a link between the highest education and the grade next below it.

But the limit of time proper for a President's address has now almost been reached. I thank you sincerely for the kindness and patience with which you have heard me. In conclusion, I would only say how entirely I share a conviction which has been expressed by one to whose ability, to whose generous enthusiasm and unflagging efforts the cause of education in this country owes an incalculable debt—I refer to Mr. E. B. Sargant. Like him, I believe that the progress of education in all its grades, from the lowest to the highest, is the agency which, more surely than any other, will conduce to the prosperity and the unity of South Africa. For all workers in that great cause it must be an inspiring thought that they are engaged in promoting the most fundamental and the most far-reaching of national interests. They are endeavouring to secure that the men and women to whom the future of this country belongs shall be equal to their responsibilities and worthy of their inheritance. In that endeavour the sympathies which they carry with them are world-wide. As we come to see, more and more clearly, that the highest education is not only a national but an Imperial concern, there is a growing desire for interchange of counsels and for active co-operation between the educational institutions of the Colonies and those of the Mother Country. The development of education in

South Africa will command keen attention, and will be followed by earnest good wishes, not only in England but throughout the British dominions. One of the ideas which are bound up with the history and the traditions of our English public schools and Universities is the idea of efficient work for the State. Those institutions have been largely moulded, from generation to generation, by the aim of ensuring a supply of men qualified to bear a worthy part either in the government of the nation or in professional activities which are indispensable to the national welfare. In our own time, and more especially within the last thirty years, one particular aspect of that idea is illustrated by the closer connections which have been formed between the Universities and the higher branches of the Civil Service. The conception of work for the commonweal is in its turn inseparable from loyalty to those ideals of character and conduct by which English life and public policy have been built up. It is by the long and gradual training which such ideals have given that our race has been fitted to grapple with responsibilities which have inevitably grown, both in extent and in complexity, far beyond anything of which our forefathers could have dreamed. That training tends also to national self-knowledge; it makes for a sober estimate of our national qualities and defects; it quickens a national sense of duty to our neighbour. The munificence of a far-sighted statesman has provided that selected youths, whose homes are in this land, and whose life-work may be here, shall go for a while to England, shall breathe the intellectual and social atmosphere of a great English University, and shall learn to judge for themselves of the sources from which the best English traditions have flowed. That is excellent. But it is also most desirable that those traditions should pass as living forces into the higher teaching of South Africa itself, and that their spirit should animate educational institutions whose special forms have been moulded by local requirements. That, indeed, has been, and is, the fervent wish of men whose labours for South African education have already borne abundant fruit, and are destined to bear yet larger fruit in the future. May those labours prosper, and may that wish be fulfilled! The sooner will come the day when the inhabitants of this country, this country of vast and still indefinite possibilities, will be able to feel, in a sense higher and deeper than citizens of the Roman Empire could conceive, *Cuncti gens una sumus* ('We are all one people'). If the work which lies before us in this Section of the British Association should result in contributing anything towards the promotion of those great objects, by helping to elucidate the conditions of further progress, our deliberations will not have been held in vain.

The following Paper was read:—

Cape Education: its Difficulties and Development.
By Rev. W. E. C. Clarke, *M.A.*

A comprehensive survey of the whole subject would be impossible in the limited time available, and the utmost that can be attempted is to follow with brief criticism the development of the various stages in the light of the peculiar difficulties of the country. It is hoped that a full appreciation of these last will serve to clear the view, and perhaps to soften the judgment of those visiting these southern shores for the first time, who might be disposed to estimate our progress by a standard borrowed from more favoured lands.

The historic development must first be noticed. In 1652, under the leadership of Van Riebeek, a permanent settlement was made at the Cape of a number of the servants of the Dutch East India Company, most of them soldiers and sailors, and many not of Dutch origin. Severe restrictions, imposed in the interests of the company, hampered the energy of these first settlers, even sea-fishing being restrained, and the Colonists being compelled to follow a pastoral and agricultural life. The Huguenot exiles in 1688, few in numbers, but numerous in proportion to the whole population, by intermarriage with the original settlers, affected strongly the subsequent character of the race, and the forcible suppression of their

own language led to the modification of the adopted one into the interesting form now surviving in 'the Taal.'

In the absorbing cares of a new settlement, little attention was paid to education, and the office of schoolmaster was for many years combined with that of 'Ziekenrooster,' or sick visitor; later, with that of 'precentor' to a country church. The disturbed state of Europe at the close of the eighteenth and the beginning of the nineteenth century affected the Cape, leading to its passing finally under English rule in 1806. The arrival of the British settlers in 1820 introduced a new element into the population of the Eastern Province, giving it a distinctive character to-day. Although a few schoolmasters were imported from Scotland in 1822, and the South African College founded in 1829, there was no organised scheme of education until the introduction, in 1839, of the 'Herschel System,' based upon certain recommendations of Herschel, the astronomer, who resided at the Cape from 1834 to 1838. A Superintendent-General was appointed, Mr. Rose-Innes, who acted as inspector of all schools for twenty years. Certain 'Established' schools, entirely supported by Government, provided instruction to the burgher children in English. Other schools receiving subsidy only were called 'aided schools.' The great difficulty continued to be the provision of education for a thin population scattered over an enormous pastoral area. The itinerant schoolmaster was chiefly employed, teaching a few months here and a few months there, imparting in that brief period all the instruction many children ever had. The pastoral habit, and the isolation of the farmhouses, tended to develop that character of independence so marked in the farming community to-day. For the problem of providing education for the rural population various solutions have been offered by Education Commissions and experts from time to time, but the question is still a most serious one. The progress of education during Mr. Rose-Innes's term of office was quiet and steady, the most remarkable development taking place towards the close of that period in the appointment of a Board of Seven Examiners, the nucleus of the present University of the Cape of Good Hope. Certificates were to be granted of a standard corresponding to that of a degree in arts in Universities in the United Kingdom.

When Dr. Dale assumed office, in 1859, the 'Herschel System' had practically served its purpose, and an Education Commission, appointed in the early sixties, led to the Education Act of 1865, the basis of the system in operation to-day. A local guarantee was first necessary, and the Government subsidy was to be on the principle of pound for pound for schools for the children of such parents as could afford to pay half the cost. Other schools of a lower class were designed for the poorer Europeans and the aborigines. A Board of Guarantors, appointed every three years, was responsible to the Government for the proper conduct of each school, but the weakness of the whole system lay in the lack of provision for continuity and permanent buildings. The highest tribute to Dr. Dale's administration lies in his success in enlisting in the management of the schools the co-operation of so many of the best representative men in the colony. In the larger centres the system worked satisfactorily, but in small villages and country districts the life of the school was often precarious. In 1872 the appointment of two deputy-inspectors relieved the Superintendent-General of that part of his duty. In the following year came the establishment of the University, superseding the old Board of Examiners. It was to be an Examining University, like the London University, granting degrees in arts, law, &c., and certificates in land surveying. Grants were to be issued to certain institutions preparing for these higher examinations, but, unfortunately, still on the pound for pound basis.

In Elementary Education the lack of teachers continued to be the great obstacle. The establishment of a Normal Institution in 1840 had produced nothing, and the attempts at developing a pupil-teacher system had also failed to remedy the defect. In 1879 the Dutch Reformed Church established a Normal College, which, under Mr. Whitton, has rendered great services in the last twenty-five years.

Denominational effort had also contributed its share to the development of education, the Diocesan College at Rondebosch being the most distinguished of

such institutions; but many others, although entirely unaided by Government, doing excellent work, and holding their own in competition with the more fortunate Public Schools.

Another Education Commission, in 1879, advised the division of the functions of the Superintendent-General between two officials, an increased number of inspectors, the removal of language restrictions in the medium of instruction, and the substitution of corporate bodies with rating powers for boards of guarantors. Parliament gave effect to some of these recommendations, but the guarantee system was left unchanged.

An Inspector-General of Schools, Mr. Ross, appointed in 1882, published a report of remarkable importance, pointing out especially the unique character of the Education Department as an autocracy in the midst of responsible government, and indicating the question of rural education as the chief difficulty, and the training of teachers as the most urgent want. He advised the employment of itinerant teachers for remote districts; but the longer experience of Dr. Dale led him to describe this suggestion as impracticable, as such a 'vagabond' life had failed to attract competent men. He preferred the subsidising of Private Farm Schools, with even five children enrolled. Other criticism at this time called from him a defence of the guarantee system, as providing a check on extravagance and securing the aid of those chiefly interested in the success of the schools.

Another Education Commission, in 1891, besides suggestions affecting the agricultural population, technical education, and the question of school boards, made the following pronouncement on the language question: 'The choice of the linguistic medium and the decision as to whether it should be double or single seems to be a matter fairly within the parents' sphere, and neither the Education Department nor any School Board should be empowered to make either Dutch or English the sole medium of instruction in any school.' Parliament had already, in 1882, removed all language restrictions.

The fact that the Superintendent-General has been an autocrat has had this advantage, that each occupant has, during a long term of office, been enabled to develop a consistent policy. The personality of the present Superintendent-General, who took office in 1892, has impressed itself strongly on Cape Education. The thorough organisation of Elementary Education, the development of an extensive pupil-teacher system, and the training of teachers have achieved great results. The latest Blue-book shows 2,700 schools in operation, 1,400 of these being for European children, with an enrolment of over 60,000; there are 28 inspectors, besides a number of departmental instructors in special subjects. Notwithstanding the large increase in the number of schools, the percentage of certificated teachers in those for Europeans is 71, the proportion being lowered by the lowest class of schools.

This satisfactory result has been achieved partly by the development of training-schools and other means of instruction for pupil-teachers, and also by an extensive system of Vacation Courses of Lectures by experts for the improvement of teachers in schools.

The development of boys' and girls' handiwork has been a marked feature of the new *régime*, and an annual exhibition of work and departmental examinations in this, as well as in science and other subjects, have proved a great stimulus. But as regards such tests and incentives, local examinations instituted by the University have for years provided a field for competition among all schools, and have been so sought after as to assume, in the opinion of some, an undue degree of importance.

Cape education has all along developed very much on its own lines, and it has been the merit of the administration throughout to move forward less by radical changes than by adaptation of existing methods and machinery. This is evidenced in the remarkable increase in good school-buildings, a result gained in spite of the lack of continuity in the school committees, and without sacrificing the pound for pound principle. The Building Loan Scheme is probably Dr. Muir's most successful achievement. From the outset secondary work was combined with primary in the better schools, but during the last few years between thirty and

forty High Schools have been established, with a special curriculum arranged for them, leading up to the matriculation certificate of the University. The new Education Act, while retaining committees for individual schools, will provide School Boards for municipalities and large areas, with rating powers and with control over the committees in their area. One-third of each Board is nominated by Government.

A few institutions preparing for the University certificates and degrees were subsidised under the Higher Education Act of 1874, but as the number of students increased, the idea arose of uniting the work of these separate colleges into a Teaching University. While vested interests and keenness of rivalry have hitherto prevented such unification, the development of these separate colleges has proceeded rapidly, and it seems likely that the Teaching University of the future will consist of certain constituent colleges. That these shall not be too many, and that their relation to the University shall be a satisfactory one, are the difficulties involved in this question. The Rhodes Scholarships, while benefiting the individual holders, will also further Higher Education if made post-graduation scholarships; in the original scheme they might have tended to do actual injury to Higher Education in the Colony.

A School of Mines was instituted at the South African College in 1896, and the students now complete their course at the Johannesburg Technical Institute.

While the progress of education has thus proceeded satisfactorily along various lines, it cannot be said that the position of the teacher has improved in a corresponding degree. It is true that the increased influence of the body of teachers is the most remarkable fact in modern education, and the Union of Cape Teachers in the South African Teachers' Conference, with its branches all over the country, has enabled them to speak with a strong voice on important questions, and to combine for purposes of mutual defence; but it is matter for regret that so great a proportion of time and interest has been devoted in their meetings to questions of salary, pension allowances, and other factors making for the comfort of their position. It should not be necessary for teachers to have to assert their rights and to impress their claims on the rest of the community. The new Education Act arranges for greater security of tenure and for improvement of salaries, but satisfactory provision has yet to be made for pension on retirement. 'The teacher should be removed beyond fear of want and anxiety about financial concerns. The community is not in a healthy condition in which education is not held in honour.'

THURSDAY, AUGUST 17.

The following Papers were read:—

1. *The Teaching of Science. By* Professor H. E. ARMSTRONG, *F.R.S.*

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2. *The Development of Technical Education in a New Country. By* G. FLETCHER.

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3. *The World of Words and its Exploration. By* Dr. J. A. H. MURRAY.

FRIDAY, AUGUST 18.

The following Papers were read:—

1. *Rural Education appropriate to Colonial Life and Agriculture in South Africa. By* A. D. HALL, *M.A.*

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2. *The Higher Education of Women in South Africa.* *By* Miss E. M. Clark.

Limitations of the Term.—In almost any country, and assuredly in any other land where English is the language of the State and of schools, the connotation of the term 'higher education' would be strictly limited to College and University work above the grade of matriculation. But in South Africa, a comparatively new country, the term may be allowed a somewhat broader and more general significance, so that it may be understood as including (1) secondary or High School education; (2) Normal or Training-School education; (3) Collegiate or University education. From the outset certain peculiarities characteristic of the country should be borne in mind: (1) the differences of standard, nationality considered, as among Colonial Dutch, Colonial English, and real Europeans; (2) the differences of standard, locally considered, as between town and country education; (3) the popularly accepted differences of standard for boys and girls.

Provision for such Education.—The number of schools having the technical right to the name 'High School' is comparatively small; but all of the 'A 1' public schools are doing some work of this grade, while many of them are offering instruction in all the highest standards, including matriculation. Statistics for 1904 report 2,331 pupils in High School grades, without specifying as to sex, though here it is safe to say that the girls are in the minority. . . . Very different in this respect is the case with the three 'European' Training-Schools for pupil teachers and others, which report a very striking majority of female students. Of these one is in the eastern division, and two are in the western. The specific object of these three institutions is that of giving instruction in the principles and methods which lie at the base of successful teaching: 284 students represent the enrolment for last year. . . . In four institutions of College grade, preparing for the Cape University examinations, young women are now following the prescribed courses of study; the total registration, however, is not over fifty, and a very large majority of these women students are in the intermediate class.

Changes in Standard.—Forty-five years ago there existed in the whole country only one large school for girls; twenty-five years ago at least six had been founded, and were in successful operation. No one of these, however, at that time was doing anything like college work, nor was matriculation then regarded as a *school* examination. Reading, writing, elementary arithmetic, with 'accomplishments,' had been up to that time considered all that was necessary for a girl to know for her own good, while there existed little or no conception of training or education for the sake of imparting knowledge to others. . . . The development has been slow but steady. The grade-standard has advanced, as has also the generally accepted standard of public opinion, in both city and rural communities. One very important element in this advance, so far as the education of women is concerned, has been the growing necessity for self-support, with the increasing strictness of requirement on the part of the Department of Education, a strictness which has been applied in due proportion to schools of all grades. According to the official report of the Superintendent-General for 1904 the percentage of 'female teachers in the seven most important classes of schools' varies from 49·13 to 89·33, an indication of a great change during the quarter of a century in the general attitude toward the question of the right of young women to teach and to be taught.

The University System.—The University of the Cape of Good Hope is exclusively an examining body, having the right to grant academic degrees. Five teaching institutions or colleges prepare students for the examinations leading to the grades—Intermediate, B.A., and M.A. There has never been on the part of the University any discrimination of sex in the matter of eligibility to the examinations given, or the degrees conferred. In most of the Colleges co-education exists, while during the past few years several scholarships based on competitive examinations have been taken by women.

The Situation and the Outlook.—With reference to the future, even the immediate future, several important topics suggest themselves as worthy of con-

sideration: (1) the actual supply of teachers in relationship to the demand; (2) the advantages and disadvantages of bringing in trained educators from England and elsewhere; (3) the possibilities of partial self-support for women students; (4) a study of the methods of higher education here and in other lands; (5) suggestions as to possible future developments, regard being had to the special conditions of the country. . . . These points, however, can be only named, not developed, in so brief an outline.

Causes of Small Increase.—The slow advance in the number of women students registered by the Colleges of this country is usually attributed to one of two causes: (1) lack of interest; (2) lack of means. Into the reason first named may be read the meaning—lack of desire for the advantages offered, or of appreciation of their real value; several good authorities in the educational world regard this as the fundamental reason. Others, however, are equally sure that the expense of a College course, or even the immediate necessity for bread-winning, lies at the root of the fact that now, nearly twenty years after the granting of the first Cape University degree of B.A. to a woman, there are throughout the country fewer than fifty women students preparing for the University examinations. In other lands, where the paternal governments are less fatherly than here, much more is done in the way of self-support by undergraduates of both sexes, even while pursuing their studies. Yet it must be acknowledged that the difficulties are greater here than in those countries where a student who has 'worked her way' from matriculation to B.A. is not an anomaly.

The End—the Means and the Woman.—The higher education of women is a comparatively new factor in the growth of this country, and up to the present there has been very little conception of such education for its own sake, or for any other purpose than as a means to an end—the end being an academic degree which will open the way to a better position in the teaching profession than it would otherwise be possible to obtain. One would expect this to be true of the advanced classes in the Training Schools, but it is almost equally the case in the Intermediate and B.A. grades of the Colleges under the University. Whereas, in England, to some extent, and in the States to a much more noticeable degree, girls go to college for the sake of the social life, or through pure interest in some special line of study; or even, in some families, as a matter of course, the situation in this country is as yet more nearly akin to that of Germany or Switzerland, where the woman student is still in some degree a *rara avis*, therefore more or less conscious of herself, her position, and the serious phases of collegiate life. . . . The higher education of women in this country has an immediate and a present interest, not only because of what has been and is, but also because of the real need that exists, and because of the unlimited possibilities of future development.

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3. *The Disabilities of the South African Schoolboy.* *By* W. W. WAY, *M.A.*

Want of continuity between home and school life is, as in England, one of the schoolboy's greatest disadvantages. South Africa is a land of farming, and in the holiday distractions of farm life the schoolboy forgets all the lessons of discipline and progress learnt in the previous quarter. His father, utterly dependent upon the smiles and frowns of Nature, talks of nothing but the weather and the crops, and reserves his fund of general conversation for his fellow-farmer at the periodical show or stock-fair. His son grows up with a total lack of general information, and the rarer son of the professional man, who hears intelligent table-talk, soon outdistances him in the class-room. He runs wild at home, and his father, who thinks that the return to school will bring back soon enough the reign of discipline, too often, pathetically enough, is glad to send him back to school to get rid of him. Yet the schoolboy is rarely seen to better advantage than when helping to entertain his father's guests. The isolation of farm life, which tends to lack of discipline and lack of general information, has developed that birthright of the South African, a graceful and generous hospitality.

The seemingly innocent conditions of sunny skies and bright atmosphere must be sternly arraigned before the tribunal for their malign influences upon the school-boy. The land- and sea-scape of the Peninsula, the Karroo stretching straight and level to its boundaries of purple hills, the rolling bush and forest of the Eastern Province, must be charged with the crime of dwarfing the intellectualities, without fostering the imagination, of the youth which grows up beside them. A savage may in a blind, unreasoning way appreciate the beauties of his native scenery, but it is the trained and educated mind which realises to the full the beauties of natural landscape, and the very charm of his surroundings tempts the South African boy from that settled study which would enable him to see with a more seeing eye the majesty and grandeur of his home. Even in the towns the bloom upon some distant mountain will attract the boy from book and study to open-air wanderings. British fog, or rain, or sleet, will drive a boy in spite of himself to some snug corner of his school library. In South Africa, when all Nature smiles without, a library is a prison and books are fetters. And so there is no real love of literature in the country, no taste for poetry, and little real culture. People do not learn in their boyhood rational methods of employing their leisure time.

Moreover, this wealth of sun and ozone is a gift which our young African Midas may well ask the gods to recall. At seventeen he is in the spring of his life, a giant in thew and sinew, a very Saul in stature, and his fancy turns lightly to the neighbouring girls' school, where the lavish sun has gifted girls of fifteen with the growth and passions of women. It is no uncommon thing to find boys and girls in a mixed school engaged to one another, or to someone in a lower standard. And this rapid growth of body too often takes place at the expense of the brain, and young giants arrive at school who, good fellows and hard workers though they be, have no chance of ever making any intellectual progress.

When the emigrant or exile of any race, under stress of political grievance or religious persecution, turns his face to the trials and dangers of an unknown land, his new life is characterised by a stern simplicity, an unwavering uprightness, a humble trust in God. God is the moving and controlling spirit of that wild nature in which he finds himself. Lurking savage and beast of prey sharpen in him a sense of alertness and self-reliance. Life becomes more precious the more it is menaced, the love of wife and children more engrossing when there is such risk of losing both. The pioneer becomes hero and saint through his environment of danger and solitude. But as time passes, and forest and savage retreat before the axe and gun of the settler, villages arise and security reigns where fear was lord. Men trust less in a God whose protection they seem less to need. The stern habits of penury and solitude give place to the vices of society and civilisation. Of all the evils that ensue, none has such far-reaching effects as the proximity of the conquered and subject savage race. In South Africa the pious Huguenot and the fanatic Voortrekker, who trusted in God and kept the powder of their muzzle-loaders dry for operation upon lion or leopard, Zulu or Hottentot, have sadly deteriorated since those early days. The 1820 settler, who struggled with pests and Kaffirs in the district of Albany, was a better man than his prosperous descendant, with his smiling farm and his slave population of black farm-servants.

The young mother yields her babe to the tender mercies of some Kaffir girl or woman. What dangers of falls, of neglect, of dirt, of disease is not the child exposed to? The youngster learns to toddle, and his earliest playmates are the naked children of herdsmen and labourers, from whom he learns to shout instead of to speak, to grunt instead of to articulate, to steal, and to lie. For if it be true that the descendants of truth-loving British and Dutch have fallen into habits of untruth, no surer reason can be found than early intercourse with lying natives.

When the boy grows into a lusty stripling his former playmate has fallen in the scale. He is now a little lower than the dogs, who receive less kicks and curses. The recent Pelser case, of undying infamy, shows how lightly estimated are the results on native life if a stirrup-iron is swung too heavily or a sjambok laid on too cunningly. Along with this reckless disregard of human life and personal dignity comes the degradation of manual labour. Hard work consists in

supervising the toil of Kaffirs, with whom it is degrading to labour. It had been better for the white man if, as in America and New Zealand, the black had been almost entirely annihilated, for the proximity of the conquered race diminishes the sanctity of human life, lowers the dignity of labour, and imperils at the fountain-head the health and morals of the young South African.

The disadvantages of bilinguality lie like a curse of Babel on the young South African, who can graduate from the Cape University without being able to write either good English or good Dutch. In the Dutch districts he speaks an uninflected and ungrammatical jargon; in most of the English districts he speaks bad English, and rarely pronounces an initial aspirate. If he has his choice of the two languages, he follows the line of least resistance in a hot country, and speaks the patois that has few words, no grammar, and no inflections. 'Man jong,' he says in playground or street. 'Ik is half ge-kill van de warmte' ('I is half kill with the heat'), and in his class-room ten minutes afterwards writes, 'The women is being kill by the soldiers.' The Cape University examiners are unanimous in their condemnation of his prevailing style of composition. Grammatical Dutch suffers as well, for the English boy tackles it at what he thinks an unfair advantage, while the Dutch boy approaches it as if he knew it already, with disastrous results. It would be better for the country if English, Dutch, Hottentot, and Bantu all talked Esperanto, for the present bilinguality involves much friction, much waste of time, and great loss of power.

There can be no denying that the South African racial question has laid its peculiar curse upon the country. It is impossible to banish it entirely from schools, but a wise schoolmaster may do much to counteract the intrigues of the politician and the fanaticism of the minister. The best object-lesson on the matter has recently been furnished by a meeting of the Native Political Association, at which the President openly declared to his coloured brethren that the time had come for asserting that the country belonged to them. I do not believe seriously in the possibilities of a native rising, but I do realise that the quarrel of the future will be not between English and Dutch, but between black and white, and I would welcome a bloody native insurrection if it could bring home to the younger generation, at any rate, that the school should not be made the battle-ground of a struggle between the two white races, that the edged tool of the native vote should not be played with by either political party, but that the attention of all white men should be earnestly devoted to the solution of this most critical question.

The peculiar conditions of the country have not, curiously enough, produced a unique system of education. The young South African is stretched upon the Procrustean bed of English and Scotch standard codes, and his mental pabulum is the same as that meted out to the son of the British workman in a crowded city. There are no real technical schools, and perhaps they are not wanted, except as a preparation for mining courses; but in a land of farming there is but one agricultural college, and that a consistent failure. The farmer's son continues to think his father's method of farming the best in creation, and if he goes to school at all, he busies himself with tonic sol-fa, and the new geometry, and graphical algebra, and impossible problems worked to six places of decimals, while around him lie unsolved all the problems of drought-resisting foodstuffs and food-producing animals, problems into the experimental solution of which he would rush with eager enthusiasm.

Recent debates on educational legislation in the Cape House of Assembly have shown that the schoolboy is still to be made a political shuttlecock, that all interest shown in his welfare and his educational efficiency is mainly fictitious. In England and Wales the object of the pupil's existence is to keep alive the flame of sectarian controversy; in France his *raison d'être* is to pass by hard-and-fast examinations into the Government service; in Germany he is expected to train himself as an intelligent factor in the military and industrial advancement of the Fatherland; in America he exists in order that Americans may point to him as the finest thing on earth in the way of educational training; in South Africa he has his being in order that he may be looked after by a local committee. One political party in the country was all for school boards, the other all for school com-

mittees, two totally different and mutually contradictory entities. An extraordinary compromise has been effected, by which these two contradictory entities are to exist side by side. One of the young South African's rapidly approaching disabilities is that he is going to fall heavily between two stools.

The very nature of farming in South Africa, with the consequent paralysing distance of farm from farm, has caused the greatest difficulty in bringing home education to the farmer's children. The problem still remains unsolved. The peripatetic teacher and the travelling schoolhouse are useless, because continuity of instruction is so necessary at this stage; while the farm school at present in vogue is damned at once by the multiplicity of different standards simultaneously at work under one teacher, the lack of class emulation, and the noise and confusion going on in one small room. The only remedy, the systematic establishment of large district boarding-schools at convenient centres, with grants to indigent farmers, is made impracticable by that lack of money to be spent on education to which allusion will be made later.

One cannot but deplore the scarcity of large boarding-schools in South Africa, those little states in which a boy, as he manages a debating society, or a games club, may learn, not too soon in life, lessons of organisation and control, of discipline over himself and others. That lamentable lack of respect towards elders and betters, only too evident in all colonies, is mainly due to the fact that boys have not learnt at school that awe and respect for their seniors which a junior in an English public school feels for the giants and heroes of the sixth form. In South Africa a small boy in Standard III. may be on terms of impudent familiarity with a man of twenty in an intermediate class. There are in South Africa only one or two schools, mostly denominational, where these sound principles of early respect are rigidly inculcated.

The early type of teacher, the Buonaparte Blenkins of Olive Schreiner's 'South African Farm,' has left his mark on present-day education in the suspicion with which the teacher is still regarded by many parents. Anyone who could read or write, escaped convict or deserted soldier, took up the profession of teaching as a *dernier ressort*, and it has taken some time for the schoolmaster of modern type to win back the confidence and affection of his pupils. Added to this, some districts were so isolated in the early days of settlement that the teacher and the clergyman hardly reached them, and this almost barbarous state has left its trace on the intellect and on the morals of the third and fourth generation.

Nothing could have a worse effect upon the young South African's education than the fact that teaching is in most cases a despised, because an underpaid, profession. There are a few posts of dignity and competence, but the large majority of teachers are miserably paid. The male pupil teacher is becoming as rare as the æpyornis, for a boy of spirit and intelligence will make a living more quickly in almost any other walk of life. The Education Department deplores the lack of efficient teachers, but will not adopt the obvious remedy. Teaching will soon fall mainly into the hands of women living on the spot; and, great as is the need of their infinite patience, their innate kindliness, and their instinctive motherhood in the lowest classes, there are lessons to be taught boys which only a man, who has been a boy himself, can teach. The younger generation of South Africa is thus cut off from a noble profession, for a capacity for martyrdom is not one of its virtues.

There are few large towns in South Africa, and the curse of the small village, with its local jealousies and slanders, cannot but have a bad effect on the young. Every clerical synod in the country deplores the increasing amount of scepticism and irreligion. The Temperance adherent, the Anti-tobacco Leaguesman, and the Anglican advocate of definite religious teaching all have their special reason for this sad state of affairs; but the true reason is more to be found in the close juxtaposition of the various branches of the Christian Church as they jostle one another in the small villages. The young South African is also tending to become a hypocrite, for only in America are there more religious societies for the young, and every boy and girl wears some distinctive badge of Christian profession. I have heard of a young rascal, caned several times during the week for lying,

cheating, and stealing, go to a Christian Endeavour meeting in order to pass a note during the opening prayer to his *inamorata* for the time being, and then pray fervently that his form-master may be led into the right path. The consequence is that in no other country is practical morality so entirely divorced from professed religion.

But the greatest disability of the young South African is the lack of money spent upon his education. This money is dependent on drought or rain, on slumps or booms in the share market. In the seven fat years the eldest son may receive a good education, in the seven lean years his younger brother is kept at home to feed sheep or ostriches. There is no steady golden stream, no generous endowment, as in America. Economy is the fashion in all the Government departments, but economy in education is the grossest profligacy of the State's greatest resource, the intellectual potentialities of her children. The consequences of this paucity of money, this lack of endowment, are terrible. There are few beautiful school buildings, and consequently little habitual training in that fine sense of artistic proportion which has made the Japanese Empire what it is to-day. If a boy's school associations are to be of an ill-paid schoolmaster, of a playground ten yards square filled with old papers and broken rubble, of an oblong rectangular building covered with cracked and dirty plaster and roofed with corrugated iron, his imagination, his feelings, his sympathy will suffer. There are few real scholars turned out by the country, as a consequence of the massed effect of all these disabilities of environment. In law alone, the one dish in the endless bill of fare that he has tasted nothing of in South Africa, does the young South African shine when he visits other countries.

It is solely lack of endowment which confines the Cape University to the function of examining schools, which thwarts research work and higher studies, and has eliminated that highest function of a university, a corporate residential life. The young South African is cut off from that golden arena of physical prowess and intellectual emulation which is the birthright nowadays of British and American youth, when as a man he rejoices in his strength, and as a sentient being he feels his mind moving for the first time through the great world-problems of life and death, of good and evil. A residential South African university, such as the late Cecil Rhodes, but for the jealousy of vested interests, would have erected on the slopes of Table Mountain, with a thousand students drawn from all parts of the country, would be an asset worth a hundred mines, a million miles of railway.

Money may be the root of all evil; it is the want of it which is the curse of education in South Africa at the present moment. The young South African has all the makings of a noble manhood in him. With proper guidance he becomes a magnificent athlete; with right treatment the generous and hospitable and kindly side of him prevails over the ignorance and prejudice and craftiness which he too often inherits in his blood; in his studies he shows a desire for higher knowledge and a capacity for hard and steady work which almost amount to genius. But bricks cannot be made without straw, and until magnificent endowment of education has put fine schools and noble universities within his grasp at a moderate cost all these latent possibilities will remain dormant.

JOHANNESBURG.

TUESDAY, AUGUST, 29.

The following Papers were read:—

1. *The Changes in the Dutch Language since its Introduction into South Africa.*[1] *By* Dr. J. BRILL, *Ph.D.*

2. *Native Education.*[1] *By* E. B. SARGANT, *M.A.*

3. *Recent Improvements in the Education of Infants, with Special Application to the Transvaal.*[1] *By* Miss E. A. WELLDON.

4. *Manual Instruction in the Transvaal.*[1] *By* T. W. LOWDEN.

5. *The Teaching of Modern Languages.*[1] *By* H. W. ATKINSON, *M.A.*

WEDNESDAY, AUGUST 30.

The following Papers were read:—

1. *The Teaching of Agriculture.*[1] *By* F. B. SMITH.

2. *Forestal Education.*[1] *By* T. R. SIM.

3. *The Teaching of Architecture.*[1] *By* R. G. KIRKBY.

4. *Education on the Veldt.*[1] *By* J. H. CORBETT.

[1] These Papers are published in full in a small volume issued by the Transvaal Technical Institute, Johannesburg.

FRIDAY, SEPTEMBER 1.

The President, Sir Richard Jebb, again delivered his Address, for which see p. 597.

The following Papers were read:—

1. *Progress of Education in the Transvaal since the War.*[1] *By* H. WARRE CORNISH.

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2. *Education in the Orange River Colony.*[1] *By the* Hon. HUGH GUNN, *M.A.*, *B.Sc.*

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3. *Education in Rhodesia.*[1] *By* GEORGE DUTHIE.

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4. *The Prospects of the Secondary Schools in the Transvaal.*[1] *By* C. D. HOPE, *M.A.*

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[1] See footnote on page 615.

DESIGNS
FOR THE SOUTH AFRICA MEDAL.
By FRANK BOWCHER.

APPENDIX.

SOUTH AFRICA: 1905.

[PLATE V.]

I.

Narrative and Itinerary of the Meeting of the British Association in South Africa.

[WITH TWO MAPS.]

The Seventy-fifth Annual Meeting of the British Association for the Advancement of Science was held in South Africa, on the invitation of the Governments of the several Colonies and of Rhodesia.

The work of organisation at home was entrusted to a special Committee of the Council, comprised of the following gentlemen: Professor Armstrong, the Right Hon. A. J. Balfour (President), Dr. Horace Brown, Sir William Crookes, Professor G. H. Darwin (President Elect), Sir James Dewar, Sir Archibald Geikie, Professor Herdman (General Secretary), Major P. A. MacMahon (General Secretary), Professor H. A. Miers, Professor Perry (General Treasurer), Sir Henry Roscoe, and Dr. P. L. Sclater. This Committee, in addition to other important duties, was charged with the selection, for the approval of the Council, of the members who were invited to join the Official Party as guests of the South African Colonies. With this Committee rested also the nomination of the pioneers who were chosen to proceed to South Africa in advance of the Official Party for the purpose of making those special investigations which had been indicated by the South African Local Committees.

In South Africa, the elaborate details of organisation and co-ordination were carried out by the Local Officers, under the general supervision and direction of Sir David Gill, as Chairman of the Central Organising Committee for South Africa, with Dr. J. D. F. Gilchrist and Mr. W. Cullen as Honorary Secretaries. Local Committees were established at Cape Town, Durban, Pietermaritzburg, Ladysmith, Johannesburg, Pretoria, Bloemfontein, Kimberley, and Bulawayo, with a Sub-Committee for Salisbury and the Victoria Falls.

A sum of 6,000*l.*, subscribed by the undermentioned Governments, was contributed as a subvention towards the ocean passages of members of the official party of invited guests:—

	£
Cape Colony	3,000
Transvaal and Orange River Colony	2,000
Natal	1,000
	6,000

A Special Fund, amounting to 3,100*l.*, was privately subscribed at home, in order to meet extraordinary expenditure in connection with the Meeting.

The number of over-sea members visiting South Africa was 380. By a special arrangement with the South African Association for the Advancement of

Science, their members were enrolled as Associates of the British Association. Following is an analysis of the tickets issued at the Meeting:—

Old Life Members	115
New Life Members	40
Old Annual Members	89
New Annual Members	411
Associates	430
Ladies	181
Foreign Representatives	16
South African Association	848
Total	2,130

The Union Castle Steamship Company granted a reduction of 30 per cent. on ocean fares to the members constituting the official party of invited guests, and a reduction of 25 per cent. to all other members of the Association.

Of the 380 over-sea members attending the Meeting, 52 sailed from Southampton in the 'Kildonan Castle' on July 22; 106 sailed in the 'Durham Castle' on July 22; and 157 sailed in the 'Saxon' on July 29.

Cape Town: *August* 15 *to August* 19, *inclusive.*—The 'Kildonan Castle' arrived at Cape Town on August 8, the 'Durham Castle' on August 13, and the 'Saxon' on August 15. The Harbour Board authorities collected and delivered free of charge the baggage of members; and representatives of the Local Reception Committee met each steamer, in order to facilitate the disembarkation of members and to introduce their hosts.

The Inaugural Meeting was held on the evening of Tuesday, August 15, at the City Hall, when Professor G. H. Darwin delivered the first part of his Presidential Address.

Sectional Meetings were held on the mornings of Wednesday, Thursday, and Friday following. Sections A, B, E, F, G, and L met at the City Hall; Sections C, D, H, I, and K met at the South African College. Presidential Addresses were delivered on Wednesday morning to Sections A, D, E, F, H, and L.

On Wednesday afternoon, his Excellency the Hon. Sir Walter Hely-Hutchinson, Governor of the Cape Colony, received members and others at Government House. In the evening, his Worship the Mayor (Mr. H. Liberman) held a Reception at the City Hall.

On Thursday afternoon, members undertook short excursions in the Cape Peninsula; and in the evening Professor Poulton lectured on 'W. J. Burchell's Discoveries in South Africa' (*vide* p. 629).

The University of the Cape of Good Hope conferred honorary degrees on the following representative members of the British Association:—*Doctors of Science:* Professor George Darwin, President of the Association; Sir William Crookes, Past President of the Association; Sir David Gill, Astronomer-Royal; Professor Porter, McGill University, Montreal; Professor Davis, Harvard University; Dr. Backlund, Director of the Nicholas Observatory, Pulkowa; Professor Bohr, Copenhagen; Professor Engler, Berlin; Professor Kapteyn, Groningen University; Professor Penck, Vienna; and Dr. Sjögren, Stockholm. *Doctors of Literature:* Sir Richard Jebb; Dr. Murray, editor of the Oxford Dictionary; and Professor Cordier, Paris.

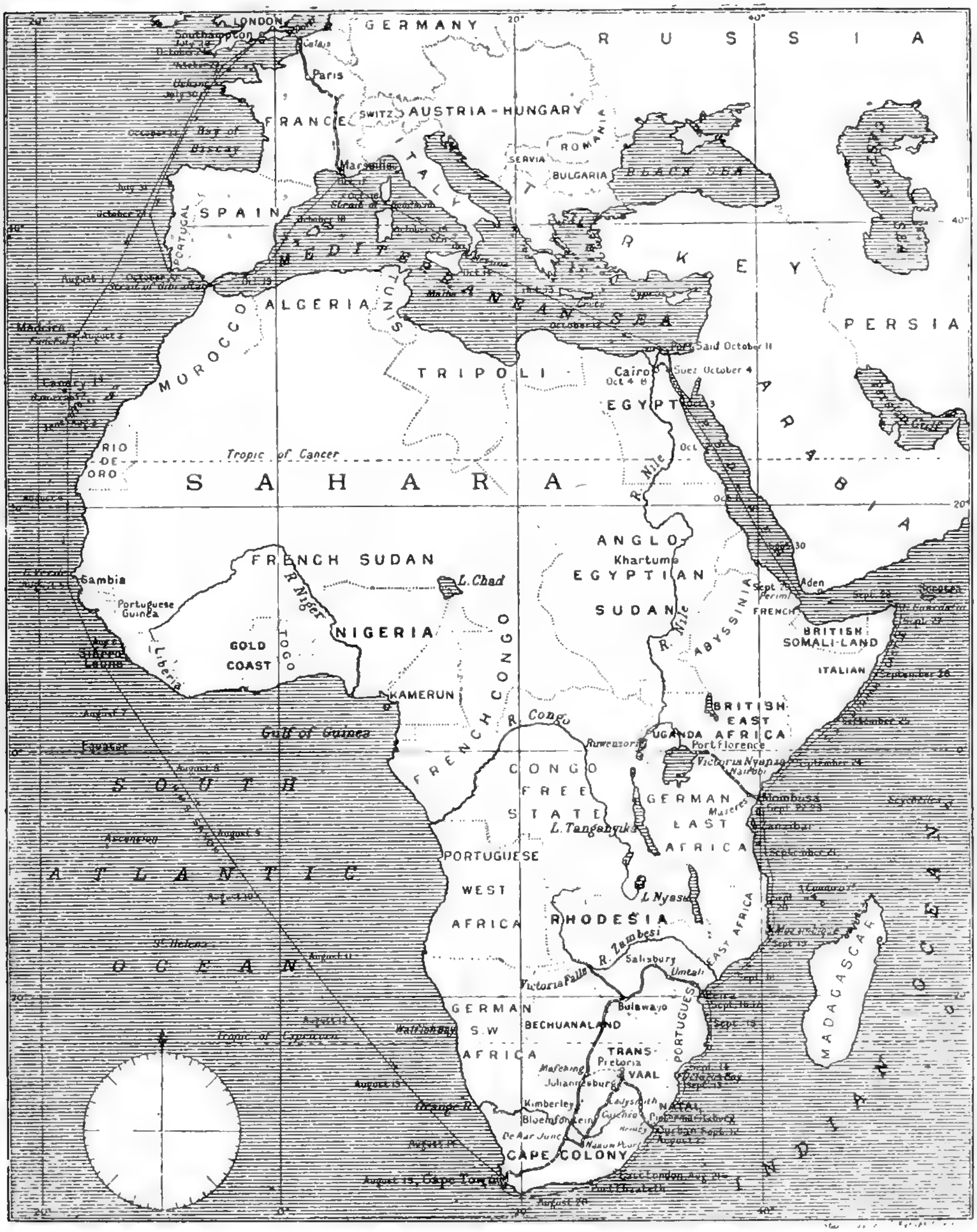
On Friday afternoon, Sir David and Lady Gill received members at the Royal Observatory. In the evening, Mr. Vernon Boys delivered a lecture on 'Some Surface Actions of Fluids.' Votes of thanks to the Government and municipal authorities and to the Local Committees were cordially adopted.

Owing to the requirements of the mail service, the 'Saxon,' conveying a large number of members of the Association, left on Friday evening for Durban, calling at Port Elizabeth and East London. The two special trains provided by the Cape Government Railways also left on Friday evening for Durban.

Saturday, August 19, was devoted to whole-day excursions, the remaining members leaving in the evening on the 'Durham Castle' for Durban direct.

The Union Castle Steamship Company was represented throughout by Mr. Robertson F. Gibb, whose delegated powers greatly facilitated the arrangements at various stages. A baggage-master, provided by Messrs. Pickford, who initiated

FIG. 1.—Track Chart.



the baggage and laundry arrangements, accompanied the party from Cape Town; and each train carried representatives of the respective railways.

Special Trains.—In addition to the two special trains provided by the Cape Government Railways, to which reference has been made, the Natal Government Railways also provided two special trains for the return journey to the Victoria

Falls. The Railways Administration was represented by Mr. B. C. Heald, of the chief traffic manager's office at Cape Town; and the four special trains were under the superintendence of Mr. F. Wille, assistant traffic-manager. Seats on the special trains were assigned to the over-sea members by Sir David Gill. Free passes on the railways were issued to the following:—

1. *Over-sea Members:*	
(*a*) Available over the Cape Government, Natal, Central South African, Rhodesia, and Beira and Mashonaland Railways	125
(*b*) Available over all but Rhodesia and Beira and Mashonaland Railways	222
2. *Members resident in South Africa:*	
(*c*) Available over all but Rhodesia and Beira and Mashonaland Railways	85
Total	432

Durban: *August* 22 *and August* 23.—The two special trains from Cape Town and the Union Castle steamships, the 'Durham Castle' and the 'Saxon,' arrived at Durban on the morning of Tuesday, August 22. In the afternoon, an official Reception was held in the Town Hall, the Mayor of Durban being in the chair; and a garden party was given by Sir Benjamin Greenacre. In the evening, Mr. Douglas W. Freshfield lectured in the Town Hall on 'Mountains of the Old World' (*vide* p. 629).

The following day was devoted to excursions; and in the evening Professor Herdman lectured in the Town Hall on 'Marine Biology and its Applications to Sea Fisheries' (*vide* p. 630).

Pietermaritzburg: *August* 24 *and August* 25.—The four special trains from Durban arrived at Pietermaritzburg in the afternoon. A Reception and garden party at Government House, given by his Excellency Sir H. E. McCallum, attracted a large gathering. In the evening, Colonel Bruce lectured in the City Hall on 'Sleeping Sickness' (*vide* p. 630).

The lecture was preceded by a civic Reception by the Mayor and Council of the city.[1]

The following day was occupied with excursions; and in the evening Mr. H. T. Ferrar lectured, by special request of the Mayor and Local Committee, on the 'Antarctic Regions' (*vide* p. 630).

Among the excursions was one to the native locations at Henley, whence a large party was conveyed by special trains. The visitors witnessed a Kaffir dance, performed by 1,000 natives, in the presence of his Excellency the Governor as supreme chief. This was followed by a native wedding.

Colenso *and* **Ladysmith:** *August* 26 *and August* 27.—Two days were spent in visiting the battlefields of Natal. Members slept at Colenso in the four special trains on Saturday, August 26, and left Ladysmith on the afternoon of Sunday for Johannesburg.

Johannesburg: *August* 28 *to September* 1.—Members, on their arrival at Johannesburg, were met by the Reception Committee and their respective hosts. The afternoon was spent in visits to the mines. In the evening, the Mayor and Town Council held a Reception at the Wanderers' Club.

The Sectional meetings, adjourned from Cape Town, were resumed on the Tuesday morning. Sections A, B, C, E, G, and L met at the Transvaal Technical Institute; the other Sections in the C.S A.R. building. Presidential Addresses were delivered to Sections B, C, G, I, K, and also again to L.

In the afternoon, his Excellency the Right Hon. the Earl of Selborne, High Commissioner for South Africa and Governor of the Transvaal and Orange River Colony, and Lady Selborne held a Reception and garden party at Sunnyside. In

[1] See page 624 for the texts of Address of Welcome and the President's reply.

the evening, Professor Ayrton lectured in St. Mary's Hall on the 'Distribution of Power.'

On Wednesday morning, work was continued in the several Sections; and in the evening, Professor Darwin delivered the second portion of his Presidential Address. Mr. Lamplugh's report on his expedition to the Batoka Gorge was given as an afternoon Address to the Geological Section (*vide* p. 292).

FIG. 2.—Route Map.

Thursday was entirely occupied with the visit to **Pretoria**. Lunches were given at the three principal hotels; and a large party visited the Premier Diamond Mine. Sir Arthur Lawley, Lieutenant-Governor of the Transvaal, gave a garden party at Government House; and in the evening Mr. Shipley lectured on 'Fly-borne Diseases' (*vide* p. 631). On the same evening, in Johannesburg, Professor Arnold lectured on 'Steel as an Igneous Rock' (*vide* p. 630).

The final meetings of the Sections were held at **Johannesburg** on Friday morning. The General Committee and the Committee of Recommendations met in the afternoon

At the Concluding General Meeting, the following Resolutions were passed:—

1. Thanks to the High Commissioner and to the Lieutenant-Governor of the Transvaal, and to the Mayor and Corporation of Johannesburg, for their reception of the British Association, and for the facilities which they placed at the disposal of the Meeting.

2. Thanks to the President and officials of the South African Association for the Advancement of Science, and to the Local Committees at Johannesburg and Pretoria, for the admirable arrangements made in connection with the visit of the British Association.

3. Thanks to the gentlemen and public bodies who hospitably entertained the members of the British Association, to firms and companies, and to the committees of clubs and other institutions who opened their premises to members, and also to the Press for their admirable reports of the proceedings.

The special trains left in the evening for Bloemfontein.

Bloemfontein: *September* 2 *and September* 3.—On the arrival of members at Bloemfontein, an official Reception was held in the Town Hall.[1] In the afternoon, Chief Justice Fawkes, on behalf of his Excellency Sir H. J. Goold-Adams, Lieutenant-Governor of the Orange River Colony, held a Reception at the Residency. In the evening, Mr. Arthur R. Hinks lectured on 'The Milky Way and the Clouds of Magellan' (*vide* p. 631).

On Sunday morning, a visit was paid to the Government Experimental and Stud Farm at Tweespruit.

Treks and Excursions.—Between the meetings of the Association at Cape Town and Kimberley, extended excursions were undertaken, chiefly by the geologists, in Cape Colony, Natal, and the Transvaal. Parties of trekkers also left Bloemfontein for Kimberley, and Pretoria for Mafeking. The latter party was welcomed at Zeerust.[2]

Kimberley: *September* 5 *to September* 7.—Members spent the whole of Monday, September 4, in the special trains, arriving at Kimberley early on the morning of September 5. After being welcomed by the Reception Committee, they paid visits to the mines. In the afternoon, a garden party was given by his Worship the Mayor (Mr. Tyson); and in the evening Sir William Crookes lectured in the Town Hall on 'Diamonds.' Sir William Crookes' lecture was re-delivered on the following afternoon.

Wednesday was occupied with excursions; and in the evening Professor Porter lectured on 'The Bearing of Engineering on Mining.'

The special trains left Kimberley on Thursday afternoon for Bulawayo.

Bulawayo: *September* 9 *and September* 10.—Bulawayo was reached on Saturday morning, after a journey of thirty-eight hours. Visits were paid to the Rhodesian Museum, which was formally opened by the President; and a Reception was held at Government House by Mr. Frank Newton, Treasurer of Rhodesia, as representing Sir William Milton, Administrator of Southern Rhodesia, who was absent in Europe.

In the evening, after a Reception in the Grand Hotel Hall, Mr. Randall-MacIver lectured on 'Rhodesian Ruins' (*vide* page 301).

An excursion to the Matopo Hills was made on Sunday, when a service was held at the grave of the late Cecil Rhodes. The special trains, carrying 330 members, left for the Victoria Falls on Monday morning, *September* 11.

Victoria Falls: *September* 12 *and September* 13.—Arriving early in the morning of Tuesday, members spent the whole of the day in visiting various points of interest at the Victoria Falls. The railway bridge over the Zambesi was formally opened by the President. The British South Africa Company, represented by Sir

[1] See pages 625, 626 for the texts of Address of Welcome and the President's reply.

[2] See pages 626–628 for the texts of Addresses of Welcome and the President's feplies.

Charles Metcalfe, Mr. Newton, and other officials, entertained a number of the official party. A special series of postage stamps was issued to commemorate the event.

The following telegrams of congratulation were received by Sir Charles Metcalfe:—

From the British South Africa Company, London, September 12: 'President and directors congratulate you, also distinguished President British Association, bridge contractors, and people of Rhodesia, on opening bridge to-day, fifteenth anniversary occupation Mashonaland. Very fitting that foremost representatives of science should be associated with inauguration of triumph of modern engineering. Regret founder of country is not alive to witness realisation of part of his great ideal.'

From H.E. Earl Grey, G.C.M.G., Governor-General of Canada, Ottawa, September 11: 'Envy your privilege receiving British Association Victoria Falls. Tell Professor Darwin hope permanent fertilisation in form of stimulated scientific activity in Zambesi Valley may result from picnic.'

The visitors left for Bulawayo in the afternoon of Wednesday.

Bulawayo: *September* 14.—Members, on their return to Bulawayo, early in the morning of Thursday, September 14, were entertained at a complimentary gymkhana on the racecourse.

In the afternoon, the trains were re-arranged, and started in sections for Beira and Cape Town.

Salisbury: *September* 15.—The Beira party, numbering 206 members, were received at Salisbury by the Mayor, the Acting Administrator, and the Resident Commissioner. They were entertained at a banquet in the Drill Hall. The trains resumed their journey in the evening.

Umtali: *September* 16.—The day was spent at Umtali, between the arrival and departure of the special trains. Members were entertained at luncheon by the Local Committee.

Portuguese officials, representing the Governor of Mozambique, met the party at Umtali, and, with others who joined at the frontier, accompanied the party to Beira.

Beira: *September* 17.—The party reached Beira early on Sunday morning, September 17, and were received by the Portuguese authorities, the Consular Corps, representatives of the Companhia de Moçambique, and representatives of the Chamber of Commerce.

A Reception was held at the Residency; and subsequently, members were entertained at luncheon by H.E. the Governor (Senhor Pinto Basto).

The 'Durham Castle,' carrying 206 members, sailed in the afternoon, homeward bound *via* the Suez Canal.

The following farewell telegram, addressed to all South African newspapers, was despatched by the President: 'British Association thanks people of South Africa for splendid reception from Capetown to Beira. Impossible adequately to repay hospitality shown, but the remembrance will remain indelible in minds of visitors from oversea. Facts observed will furnish material for many scientific memoirs, and it is likely that South Africa will be repaid by stimulated scientific activity.—DARWIN.'

The President also sent letters of thanks to the leading officers and officials.

The West Coast party arrived at **Cape Town** in the afternoon of the same day, and sailed in the 'Armadale Castle' on September 20 for Southampton.

London: The Council, at its sitting on November 3, 1905, passed the following Resolutions, which were despatched to Sir David Gill, Chairman of the Central Organising Committee for South Africa, for transmission to those concerned:—

(i) 'That the Council of the British Association for the Advancement of Science desires to place on record its high appreciation of the cordial reception given to its officers and members throughout the sub-continent by the representatives of the several Colonies and Administrations, and to convey, through the Central Organising Committee, its grateful thanks for the generous hospitalities, privileges, and

concessions extended to them on the occasion of the visit of the Association to South Africa in 1905.'

(ii) 'That the Council of the British Association for the Advancement of Science desires to convey, through the Central Organising Committee for South Africa, its cordial appreciation of the generous reception by the Portuguese representatives and authorities at Beira of the officers and members of the Association on the day of their embarkation for Europe.'

The General Committee, adjourned from Johannesburg, met in London on October 31, and the Conference of Delegates held Meetings on October 30 and 31.

In commemoration of the visit of the Association to South Africa, a fund was raised for the endowment of a Medal and Scholarship or Studentship for South African Students (see p. 631); and, with the consent of the Council, the South African Association for the Advancement of Science have prepared for publication, in four volumes, all the papers of South African interest read at the Sectional meetings.

II.

Addresses of Welcome.

PIETERMARITZBURG.

TO PROFESSOR HOWARD DARWIN, M.A., LL.D., F.R.S., F.R.A.S., PRESIDENT, AND THE MEMBERS OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

We, the Mayor and Town Council of the City and Borough of Pietermaritzburg, the capital of the Colony of Natal, and as such representing the burgesses and inhabitants thereof, desire to tender you a most cordial welcome to our city on the occasion of your visit to South Africa.

We esteem it a high honour to have so many distinguished and scientific men in our midst, and we desire to express the hope that your visit will be one of great importance to South Africa, in the advancement of science and its attendant results upon commercial aspirations.

We feel confident that members of the British Association will find that this portion of His Majesty's Empire has not been slow to take advantage of the results of science, and we earnestly hope that the present visit will bring about an interchange of intercourse which will be of immense benefit, not only to South Africa, but to the British Empire.

We trust that your stay amongst us will be a very pleasant one, and that your sojourn in South Africa will be fraught with good results in the interests of scientific research.

Signed, on behalf of the Town Council and inhabitants of Pietermaritzburg, this 24th day of August, 1905.

A. W. KERSHAW, Mayor.

D. A. V. WALKER, Town Clerk.

Reply.

TO HIS WORSHIP THE MAYOR AND TO THE MEMBERS OF THE TOWN COUNCIL OF THE CITY AND BOROUGH OF PIETERMARITZBURG IN NATAL.

SIR GEORGE HOWARD DARWIN, Knight Commander of the Bath, President of the British Association for the Advancement of Science, has the honour of acknowledging the receipt of a copy of the Address which the Mayor and Town Council of Pietermaritzburg presented to the Association on the 24th day of August

last. The beautifully illuminated parchment in which the copy is embodied will be treasured amongst the most valued archives of the Association.

The President desires to avail himself of the present opportunity of renewing his previous expressions of gratitude to the burgesses and inhabitants of Pietermaritzburg for the magnificent reception and for the generous hospitality accorded to the members of the Association on the occasion of their memorable visit to the beautiful and prosperous Colony of Natal.

The Council of the British Association cordially reciprocate the eloquent words of friendship contained in the Address; and they express the hope that the visit may afford an incentive to study and research, not only in the realms of pure knowledge, but also in those applications of science which have such diverse and supreme importance in the development of commerce.

The members of the British Association, during their long and varied journey through South Africa, have reaped a rich harvest of observation in many departments of science. The Council confidently expect that these observations will be the starting-point of many investigations on subjects having a special bearing on South Africa; and they hope that in this manner the members of the Association may be enabled in some degree to repay the deep debt of gratitude under which they lie to their fellow-subjects of the King beyond the seas.

Signed, on behalf of the Council of the British Association, this 30th day of November, 1905.

G. H. Darwin,
President of the British Association for the Advancement of Science.

Burlington House, London, W.

BLOEMFONTEIN.

To the President and Members of the British Association.

Ladies and Gentlemen,—On behalf of the members of the Philosophical Society of the Orange River Colony, we desire to join in welcoming you to our Colony and to the city of Bloemfontein. Our Society is as yet so young that we should hardly have ventured to do so, were it not that at present it is the only Society in this Colony whose aims and objects are akin to those of your great Association.

Formed only since the declaration of peace, and seeking to develop amidst all the difficulties of the work of reconstruction which has occupied the last four years, you will easily understand that it has not been possible for us to do much, or to do what we have done very thoroughly, but if we refer to what has been done or what we are proposing to do in the near future, we feel sure you will consider we are proceeding on right lines, and give promise of really useful work in the time to come.

Papers, followed by interesting discussions, have been read by Dr. Brill, Rector of Grey College, on Social Life in Bloemfontein in early days; by Mr. Lyle, Science Lecturer of the Grey College, on the Discovery and Nature of Radium; by Miss Steedman, Principal of the Girls' High School, on Adaptations in Plants in the Orange River Colony, and in June last year we were fortunate in having a lecture from Professor Hele Shaw on Aërial Navigation.

Mr. Glenday, of the Government Works Department, read a paper on Irrigation, which we have been able to publish; the Rev. Z. Lawrence lectured on Tolstoi and Modern Russia; and the Right Rev. Dr. Chandler, Bishop of Bloemfontein, gave an address on Plato and the Greek Ideals of Education: this was largely attended by the teachers of the Colony.

We have promises of papers from Dr. Targett-Adams, Mr. Stead, and Mr. Weall, the Government analysts; Dr. Pratt Yule, medical officer of health for the Colony; Major Gray, head of the Municipal Police; Dr. Mossop, Mr. H. B.

Austin, the Rev. C. S. Franklin on Native Folklore, Mr. Dewar on Entomology, Dr. Potts on Agricultural Natural History, and Mr. Ivan H. Haarburger on the work of Professor Max Müller.

The increasing number of corresponding and country members, from whom we may hope to receive notes and observations of matters of interest in their respective neighbourhoods, is distinctly encouraging.

Assuring you of the pleasure it gives us to join in welcoming you to our Colony, and hoping that you will carry home many pleasant recollections of your visit,

We have the honour to be,
Ladies and Gentlemen,
Very faithfully yours,
HORACE W. ORFORD, *Acting Vice-President.*
J. BRILL, *Past Vice-President.*
O. HATCH, *Hon. Treasurer.*
W. S. JOHNSON, *Hon. Secretary.*

Bloemfontein,
September 2, 1905.

Reply.

TO THE PRESIDENT AND MEMBERS OF THE PHILOSOPHICAL SOCIETY OF THE ORANGE RIVER COLONY, BLOEMFONTEIN, SOUTH AFRICA.

Burlington House, London, W.
November 30, 1905.

GENTLEMEN,—On behalf of the Council of the British Association, I beg leave to give you a formal acknowledgment of the receipt of a copy of the Address of Welcome presented on the second day of September last by the Philosophical Society of the Orange River Colony to the members of the Association.

The foundation of your Philosophical Society affords a proof that intellectual interests are firmly implanted in the minds of the inhabitants of the Colony; and we are convinced that conditions of economic and political prosperity will lead your Society onward from the fair promise of its youth to a flourishing maturity.

Although our visit to Bloemfontein was necessarily brief, yet it has left an impression which will not easily be effaced from the recollection of those whose privilege it was to receive such a cordial welcome and such hospitable entertainment.

I beg leave, Gentlemen, to remain,
Yours faithfully,
G. H. DARWIN,
President of the British Association for the Advancement of Science.

ZEERUST (TRANSVAAL).

THE MEMBERS OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Zeerust, Transvaal.
September 1905.

GENTLEMEN,—We, the undersigned Chairman and members of the Zeerust Municipal Council, as representing the citizens of the town of Zeerust, tender you our most hearty welcome. While regretting the brevity of your stay in our midst, we feel honoured in being accorded the opportunity of meeting some of the greatest men produced by the British nation.

We are convinced that your visit to these shores has been made at considerable personal sacrifice by some of you, but the benefit derived therefrom by this subcontinent in particular, and the whole scientific world in general, cannot be overestimated. We trust your tour has been both pleasant and interesting to yourselves, and hope that your future progress will be accompanied with the same good fortune, so that when you return to your homes you will feel satisfied that you have been fully compensated for the time, trouble, and expense offered up by you

S. J. FAUDUSSUNG, *Chairman.*
T. G. SEPHTON,
W. DICTRIA,
J. THOMSON, jun.,
ERNEST W. SWESLEY, *Members.*
J. C. TRUSCOTT,
EDWARD SEPHTON,
DURELL W. BISHOP,

Reply.

TO THE CHAIRMAN AND MEMBERS OF THE MUNICIPAL COUNCIL, ZEERUST, TRANSVAAL, SOUTH AFRICA.

Burlington House, London, W.
November 30, 1905.

GENTLEMEN,—On behalf of the Council of the British Association, I beg leave to give you a formal acknowledgment of the receipt of the Address of Welcome presented to the members of the Association who visited Zeerust; and I desire further to thank the Municipal Council for the generous reception accorded to them.

We feel sure that both for hosts and guests the visit to South Africa will prove a fruitful stimulus to the advancement of science, and to the cordial relationships established throughout our memorable tour in South Africa.

I beg leave, Gentlemen, to remain,
Yours faithfully,
G. H. DARWIN,
President of the British Association for the Advancement of Science.

FROM THE MARICO AGRICULTURAL SOCIETY TO THE CHAIRMAN AND MEMBERS OF THE BRITISH ASSOCIATION.

Zeerust,
September 5, 1905.

GENTLEMEN,—It gives us, the *farming community,* great pleasure in presenting this Address of Welcome to you to the shores of South Africa in general, more particularly to our little village, Zeerust. We are not in a position to receive you with the great pomp of the big places; but, nevertheless, we can assure you that we welcome you with a cordial welcome. Taking the object of your visit to be manifold, trusting on coming to the end of your tour, you will always be able to look back to this your visit as profitable in the advancement of science, as well as pleasurable to yourselves.

We are glad to have such a strong representative body of highly cultured members of the British Empire here, thanking you at the same time by considering this our remote part, and to have planned it so that we could meet a section of the Society face to face, hoping it will tend to strengthen the link between the people of Great Britain and her Colonies in general, and this country in particular, by getting to know each other better; the same will then be true if a representative body from South Africa should visit Great Britain.

We further trust when the time comes for you to return to your homes, from whence, no doubt, your every movement is closely watched with the greatest interest, you will be able to say that a great and permanent step has been taken in the matter of drawing together the bonds of brotherhood of science, as well as the promotion of a better feeling between His Majesty's subjects in the Colonies and Great Britain to follow.

We therefore wish you a prosperous journey and a safe return home, loaded with fresh problems to be solved, so as to add on to make life more worth living for.

We are, Gentlemen,

Yours very faithfully,

J. L. van Keerdey, *President.*
D. L. Bothe, *Vice-President.*
G. E. Bellevillestern, *Secretary.*
O. J. Vorthingen.
P. C. Snyman.
J. D. L. Botha.
F. A. Jacobs.
G. Rabie.

Reply.

To the President of the Marico Agricultural Society, Zeerust, Transvaal, South Africa.

Burlington House, London, W.
November 30, 1905.

Sir,—On behalf of the Council and members of the British Association, I beg leave to give a formal acknowledgment of the receipt of the Address of Welcome handed by you to the members of the Association who visited Zeerust. It was very gratifying to the whole British Association that the reception accorded to those of our number who passed through the important agricultural centre of Zeerust should have been so cordial.

In every part of South Africa we were met with demonstrations of friendship which never can be effaced from our memory. The relationship of science to the industries pursued in the larger towns is somewhat more obvious, although not more real, than its bearing on agriculture. The cities of South Africa vied with one another in a generous rivalry as to which should accord to us the most magnificent welcome. It was a far more difficult task for a scattered agricultural population to prove to us its kindly feeling; but you, Sir, by the hospitality shown to our members have overcome this difficulty, and I venture to assure you that we regard the Address presented to us as amongst the most interesting of the records of our journey in South Africa.

I beg leave to remain, Sir,

Yours faithfully,

G. H. Darwin,

President of the British Association for the Advancement of Science.

III.

Lectures.

Date and Place	Lecturer	Subject
Aug. 17. Cape Town	Professor Poulton............	W. J. Burchell's Discoveries in South Africa.
Aug. 18. Cape Town	Mr. C. V. Boys	Some Surface Actions of Fluids.
Aug. 22. Durban	Mr. D. Freshfield............	The Mountains of the Old World.
Aug. 23. Durban	Professor Herdman.........	Marine Biology.
Aug. 24. Pietermaritzburg	Colonel D. Bruce	Sleeping-sickness.
Aug. 25. Pietermaritzburg	Mr. H. T. Ferrar	The Cruise of the 'Discovery.
Aug. 28. Johannesburg ...	Professor Ayrton	Distribution of Power.
Aug. 31. Johannesburg ...	Professor Arnold	Steel as an Igneous Rock.
Aug. 31. Pretoria	Mr. A. E. Shipley............	Fly-borne Diseases, Malaria, &c.
Sept. 2. Bloemfontein......	Mr. A. R. Hinks	The Milky Way and the Clouds of Magellan.
Sept. 5. Kimberley	Sir William Crookes	Diamonds.
Sept. 6. Kimberley	Professor Porter	Bearing of Engineering on Mining.
Sept. 9. Bulawayo	Mr. Randall-MacIver	The Ruins of Rhodesia.

BRIEF NOTICES.

Professor Edward B. Poulton, D.Sc., F.R.S.: *W. J. Burchell's Discoveries in South Africa.*

The lecturer gave a brief account of Burchell's life, dwelling especially upon his African travels (1810–1815) from Cape Town to Litakun, near the borders of the Kalahari Desert; thence south-east to the mouth of the Great Fish River, and back along the south coast to the starting-point. The lecture was illustrated by lantern slides representing the woodcuts and plates of Burchell's classical work[1] and of his memoirs, together with specimens of his collection now at Oxford. His unrivalled skill and care as an observer and collector were shown by many examples, and it was proved by extracts from his African and Brazilian (1825–1830) manuscript note-books at Oxford that he had observed and recorded many striking examples of protective resemblance and mimicry—an astonishing anticipation of modern research.

The lecturer pointed out that the great majority of Burchell's invaluable journals were unpublished and unknown, viz., the African journal beyond August 3, 1812, and the whole of the Brazilian journal.

Douglas W. Freshfield, F.R.G.S.: *The Mountains of the Old World.*

Mr. Freshfield's lecture was illustrated by numerous lantern views of the Caucasus and Himalaya. He sketched in outline the advance made in the practical exploration and scientific appreciation of the more famous of the mountains of the old world during the preceding century, taking as his starting-point the ascent of Mont Blanc by de Saussure in 1787. Incidentally, he showed to how large an

[1] *Travels in the Interior or South Africa*, vol. i. 1822; vol. ii. 1824.

extent this advance was due to the growth of mountaineering in the technical sense of that term and to the means of communication and publication afforded by the spread throughout Europe of Alpine clubs. His survey was limited to the greater ranges—the Alps, the Caucasus, and the Himalaya—with a few words on the snows of Africa.

Professor W. A. HERDMAN, D.Sc., F.R.S. : *Marine Biology.*

The full title of the lecture was 'Marine Biology; especially in its practical applications to Fishing Industries,' and the series of facts and principles involved were illustrated as far as possible by lantern slides. The lecturer first explained the importance of 'plankton' and other minute organisms in the sea in relation to the food of man. He then passed to the competition amongst organisms in the sea, illustrated by complicated life-histories and by the protective and other devices that are resorted to. A few fishing industries were then examined, such as flat-fish trawling, oyster culture in France and Holland, and the pearl fisheries of Ceylon; and the bearing of scientific observations upon all of these was demonstrated. Finally the lecturer alluded to the excellent work which was carried on for the Cape Government by Dr. Gilchrist, the official marine biologist, and recommended co-operation between all the South African Colonies in exploring their coastal waters and exploiting the fishing industries.

Colonel DAVID BRUCE, C.B., F.R.S. : *Sleeping Sickness.*

The lecturer described the disease, showing that the incubation period might be as long as two or three years. It is caused by a blood parasite—*Trypanosoma gambiense*—which is always found in the cerebro-spinal fluid and blood of sleeping-sickness cases. One hundred natives in the sleeping-sickness area were examined, and 25 per cent. of them found to be infected; while in the non-sleeping-sickness area not a single native was affected. A tsetse-fly (*Glossina palpalis*) was found to be the carrier of the disease. The distribution of this fly in Uganda was worked out and found to correspond exactly with the area of sleeping-sickness. Wild flies caught in the sleeping-sickness area were found to be able to infect monkeys—in fact, that sleeping-sickness is a human tsetse-fly disease.

H. T. FERRAR, M.A. : *The Cruise of the 'Discovery.'*

The lecture was illustrated by lantern slides. The equipment of this Antarctic expedition included all instruments required for surveying, complete sets of meteorological apparatus, the latest pattern of pendulums *in vacuo* for determining the force of gravity, Eschenhagen self-recording magnetometers, sounding machines, electrometers, a balloon, and a great quantity of dredging tackle. The object of the expedition was 'the advancement of science.' Mr. Ferrar explained the scheme of international co-operation whereby simultaneous magnetic and meteorological observations were made by (1) the three expeditions wintering on opposite sides of the South Pole; (2) by the sub-stations at Cape Town, Kerguelen, and Christchurch; and (3) by the observations at Kew and Berlin.

Professor J. O. ARNOLD : *Steel as an Igneous Rock.*

The lecturer described a recent discovery he had made in a broken bolt, viz., that a crystal obtained under exceptionally fortunate optical conditions exhibited perfect mineral cleavage exactly parallel to the faces of the cube, thus proving iron to be a veritable mineral. It was impossible, as a rule, to obtain the microscopical conditions under which such cleavage could be recognised. The lecturer therefore suggested that, beyond the range of ordinary opaque microscopy, there existed the

clue to the sudden and mysterious fractures of steel in connection with a development of perfect cleavage. He trusted that what he had said might convey to his hearers the fact that steel metallurgy was not, as often supposed, a matter of boiling pig iron and slinging ingots, because its scientific consideration involved the highest flights of chemistry, physics, and opaque microscopy. In fact, it might well be that the answer to the question, 'What is steel?' would be involved in the answer to the question, 'What is crystalline matter?'

A. E. Shipley, F.R.S.: *Fly-borne Diseases, Malaria, &c.*

The popular title of the lecture delivered by Mr. A. E. Shipley at Pretoria was 'The Infinite Torment of Flies.' The lecturer began by referring to certain diseases, such as plague, cholera, &c., which are mechanically conveyed by flies from the sick to the healthy, and then passed on to consider those pathogenic organisms which pass some part of their life-history within the body of flies, gnats, &c. He discussed the habits of the disease-carrying Diptera, and described the various phases the parasites pass through both in man and in the insects; and he dwelt upon the biting apparatus which enables the flies, &c., to pierce the integument. Filariasis, malaria, yellow fever, sleeping sickness, and nagana were separately described, and hints were given as to the best way to combat these. In conclusion Mr. Shipley described the various tick-borne diseases—piroplasmiasis—the etiology of which has been so largely worked out in South Africa.

Arthur R. Hinks, M.A.: *The Milky Way and the Clouds of Magellan.*

The stars in general, and the coarse clusters, the gaseous nebulæ, and fifth-type stars, are strongly condensed on the Milky Way and in the greater Cloud of Magellan. The spiral nebulæ avoid the Milky Way, but crowd into the greater Magellanic Cloud to meet the Milky Way constituents with which they are associated nowhere else. This striking distribution has suggested that the key to the structure of the universe will be found in the Magellanic Cloud. If we adopt this view, we must suppose that the universe is an organic whole, and that separative forces have kept the stars and spiral nebulæ apart except in one place. But the distributions are not so symmetrical about the poles of the Milky Way as to preclude the alternative hypothesis, that stars and spiral nebulæ are in independent clouds, more or less in one plane, but not organised in one system.

⁂ *The lectures by Professor Ayrton at Johannesburg and Sir William Crookes at Kimberley were privately printed* in extenso. *Mr. Randall-MacIver's lecture is published as a Report to the Association* (*vide* page 301).

IV.

South Africa Medal Fund.

Executive Committee.

Sir George Darwin, K.C.B. (Chairman).
Professor J. Perry, F.R.S. (Honorary Treasurer).
A. Silva White, Esq. (Honorary Secretary).
Colonel A. C. Bigg-Wither.
Dr. Horace T. Brown, F.R.S.
Professor W. A. Herdman, F.R.S.
Major P. A. MacMahon, F.R.S.
H. R. Mill, Esq., D.Sc.
F. W. Pavy, Esq., M.D., F.R.S.
Professor E. B. Poulton, F.R.S.

In commemoration of the visit of the British Association to South Africa, a fund was raised, on the initiation of the President, for the endowment of a Medal and Scholarship or Studentship for South African Students.

The first Meeting of the subscribers was held in London on December 1, 1905, when the following Resolution was adopted:—

> That it be remitted to the Executive Committee to draw up definite recommendations in regard to the disposal of the Fund and the special conditions attaching to the award (including the design of a Medal), and to report at a future meeting of the Subscribers.'

The Executive Committee met on January 19, 1906, when it was resolved to entrust the design for the Medal to Mr. Frank Bowcher; and again on February 2, to inspect the designs submitted by the artist.

At the Meeting of the Subscribers held on March 2, the following Report by the Executive Committee was formally adopted; and the Council, at its sitting on the same day, in accepting the proposal made by the contributors to the Fund, authorised the issue of a circular-letter inviting additional subscriptions from the general membership of the Association.

Report of the Executive Committee.

I. The Executive Committee of the South Africa Medal Fund have the honour to lay before the Subscribers, for their approval, finished sketches by Mr. F. Bowcher of obverse and reverse designs for the proposed Medal, and to submit the following recommendations in regard to its award:—

(i) That the Fund, together with a Die for the Medal, be offered to the President and Council of the British Association for transmission to South Africa, subject to the conditions that follow:

(*a*) That the Fund be devoted to the preparation of a Die for a Medal to be struck in bronze, $2\frac{1}{2}$ inches in diameter; and that the balance be invested and the annual income held in trust.

(*b*) That the Medal and income of the Fund be awarded by the South African Association for the Advancement of Science *for achievement and promise in scientific research in South Africa.*

(ii) That, as far as circumstances admit, the award be made annually.

II. The Council of the British Association have resolved to add the balance (about 800*l.*) of the special South Africa Fund to the South Africa Medal Fund.

Signed, on behalf of the Committee,

G. H. DARWIN, *Chairman.*

SOUTH AFRICA MEDAL FUND.

(*Contributions, promised or received, up to April* 30.)

	£	s.	d.
Acland, H. D.	1	1	0
Alexander, P. Y.	10	0	0
Anderson, Miss Mary K.	1	1	0
Anderson, Dr. Tempest	5	5	0
Armstrong, Dr. E. F.	1	0	0
Atkinson, Wm.	1	1	0
Backhouse, W. A.	5	5	0
Backlund, Dr. O.	6	6	0
Baker, Sir Benjamin	52	10	0
Balfour, Arthur James (President 1904)	5	0	0
Barcroft, J.	2	2	0
Barnard, Dr. Annie T.	1	1	0
Barnard, William	2	2	0
Barstow, Miss F. A.	4	0	0
Beare, Prof. T. Hudson	5	5	0
Beilby, George	10	10	0
Benson, Dr. and Mrs. Arthur	5	5	0
Bentley, F. W.	10	10	0
Bevan, Rev. J. O.	1	1	0
Bigg-Wither, Colonel A. C.	1	0	0
Bigg-Wither, Mrs.	1	0	0
Birley, Miss C.	2	2	0
Black, Surg.-Major W. G.	2	2	0
Blamires, Joseph	10	10	0
Bohr, Prof. Christian	3	3	0
Bolton, John	1	1	0
Borns, Dr. H.	1	1	0

	£	s.	d.
Bottomley, Dr. J. T.	5	5	0
Bottomley, Mrs.	2	2	0
Boulenger, G. A.	2	2	0
Bowley, A. L	2	2	0
Bowman, H. L.	2	2	0
Boys, C. Vernon	10	10	0
Bremner, R. S. and Stanley	1	11	6
Briggs, Dr. W.	5	5	0
Brown, A. R.	1	1	0
Brown, Prof. Ernest W.	5	5	0
Brown, Dr. Horace T.	5	5	0
Browne, J. Stark	2	2	0
Bruce, Colonel David	2	2	0
Brunton, Sir Lauder	10	10	0
Brunton, Lady	10	10	0
Bryan, Prof. G. H.	1	0	0
Burbury, S. H.	10	10	0
Buxton, Francis	20	0	0
Campbell, Prof. D. H.	2	2	0
Cannan, Gilbert	1	1	0
Carhart, Prof. H. S.	2	2	0
Challenor, Bromley, jun.	1	1	0
Cheesman, W. N.	2	2	0
Cleland, Prof. John	5	5	0
Cleland, Mrs.	1	1	0
Cleland, J. R.	1	1	0
Cole, Prof. Grenville A. J.	3	3	0
Coleman, Dr. A. P.	2	2	0
Cordier, Prof. Henri	2	3	0
Creak, Captain Ettrick, R.N.	5	5	0
Croft, Miss Mary L.	1	1	0
Crookes, Sir William (President 1898)	10	10	0
Crookes, Lady	5	5	0
Cunliffe, Peter G.	5	5	0
Cunningham, Rev. Dr. W.	5	5	0
Daniel, Miss A. M.	1	1	0
Darwin, Erasmus	2	0	0
Darwin, Sir George (President)	10	10	0
Darwin, Lady	2	2	0
Davis, Prof. W. M.	2	0	0
Divers, Dr. Edward	2	2	0
Dixon, Prof. A. C.	3	3	0
Dixon, Captain George	5	5	0
Dixon, Prof. Harold B.	5	5	0
Donner, Prof. Anders	5	5	0
Drew, H. W.	1	1	0
Engler, Prof. A.	2	2	0
Evans, A. H.	2	0	0
Faulkner, J. M.	3	3	0
Feilden, Colonel H. W.	2	2	0
Ferrar, H. T.	1	1	0
Findlay, Alex.	1	1	0
Fleming, James	3	3	0
Fletcher, G.	2	2	0
Forster, Dr. M. O.	1	1	0
Forsyth, Prof. A. R.	5	5	0
Fowlds, H.	1	1	0
Fox, F. Douglas and Mrs.	10	10	0
Freshfield, Douglas	10	10	0
Fry, W., jun.	5	5	0

	£	s.	d.
Gardiner, J. H.	1	1	0
Gaskell, Dr. W. H.	5	0	0
Gray, Robert Kay	5	0	0
Green, Prof. J. Reynolds	2	2	0
Gregory, Prof. J. W.	3	3	0
Gregory, R. P.	1	1	0
Haddon, Dr. A. C.	5	5	0
Hall, A. D.	2	2	0
Halliburton, Prof. W. D.	3	3	0
Hammond, Robert	1	1	0
Harmer, Dr. S. F.	5	5	0
Harrison, Rev. S. N.	1	1	0
Hartland, E. Sidney	3	3	0
Harzer, Prof. Paul	5	5	0
Henderson, Prof. G. G.	1	1	0
Herbertson, Dr. A. J.	2	2	0
Herdman, Prof. W. A. (Gen. Sec.)	5	5	0
Hervey, Miss Mary F. S.	5	5	0
Hicks, Prof. W. M.	5	0	0
Hindle, J. H.	1	1	0
Hinks, A. R.	2	2	0
Hobson, Bernard	1	1	0
Hopkins, C. Hadley	5	5	0
Hopkinson, Mrs	10	10	0
Hudson, Prof. W. H. H.	3	3	0
Hutchinson, Arthur	2	2	0
Jacobson, N.	2	2	0
Jaffé, Arthur	1	1	0
Jeans, J. H.	2	2	0
Jeyes, Miss G.	2	2	0
Joly, Prof. C. J.	5	5	0
Jones, Evan	2	2	0
Jones, Miss Parnell	1	0	0
Judd, Miss Hilda M.	2	2	0
Kapteyn, Prof. J. C.	2	2	0
Kelvin, Lord and Lady	5	0	0
Kincaid, Major-General and Mrs.	1	1	0
Knightley, Lady, of Fawsley	2	2	0
Lamplugh, G. W.	2	2	0
Leech, Sir Bosdin	2	2	0
Lees, Mrs. A. P.	3	3	0
Lees, Dr. Charles H.	1	1	0
Lister, Lord	10	0	0
Lomas, J.	1	1	0
Longstaff, Dr. G. B.	20	0	0
Luschan, Prof. von	3	3	0
Macallum, Prof. A. B.	2	0	0
Macaulay, W. H.	10	0	0
Maccall, W. T.	1	1	0
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CONTENTS.

PAGE

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1885. *ABERDEEN, The Earl of, G.C.M.G., LL.D. Haddo House, Aberdeen.
1885. ‡Aberdeen, The Countess of. Haddo House, Aberdeen.
1885. ‡Abernethy, James W. 2 Rubislaw-place, Aberdeen.
1873. *ABNEY, Captain Sir W. DE W., K.C.B., D.C.L., F.R.S., F.R.A.S. (Pres. A, 1889; Pres. L, 1903; Council, 1884–89, 1902–05). Rathmore Lodge, Bolton-gardens South, Earl's Court, S.W.
1886. ‡Abraham, Harry. 147 High-street, Southampton.
1905. §Abrahamson, Louis. Civil Service Club, Cape Town.
1884. ‡Acheson, George. Collegiate Institute, Toronto, Canada.
1882. *Acland, Alfred Dyke. 38 Pont-street, Chelsea, S.W.

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1889. ‡Anderson, R. Simpson. Elswick Collieries, Newcastle-upon-Tyne.
1905. §Anderson, T. J. P.O. Box 173, Cape Town.
1880. *ANDERSON, TEMPEST, M.D., D.Sc., F.G.S. (VICE-PRESIDENT, 1906; Local Sec. 1881.) 17 Stonegate, York.
1902. *Anderson, Thomas. Embleton, Osborne Park, Belfast.
1901. *Anderson, Dr. W. Carrick. 2 Florentine-gardens, Glasgow.
1901. ‡Anderson, W. F. G. 47 Union-street, Glasgow.
1895. ‡Andrews, Charles W. British Museum (Natural History), S.W.
1891. ‡Andrews, Thomas. 163 Newport-road, Cardiff.
1880. *Andrews, Thornton, M.Inst.C.E. Cefn Eithen, Swansea.
1886. §Andrews, William, F.G.S. Steeple Croft, Coventry.
1883. ‡Anelay, Miss M. Mabel. Girton College, Cambridge.
1877. §ANGELL, JOHN, F.C.S., F.I.C. 6 Beacons-field, Derby-road, Withington, Manchester.
1886. ‡Annan, John, J.P. Whitmore Reans, Wolverhampton.
1900. ‡Annandale, Nelson. 34 Charlotte-square, Edinburgh.
1896. ‡Annett, R. C. F. 4 Buckingham-avenue, Sefton Park, Liverpool.
1886. ‡Ansell, Joseph. 38 Waterloo-street, Birmingham.
1878. ‡Anson, Frederick H. 15 Dean's-yard, Westminster, S.W.
1890. §Antrobus, J. Coutts. Eaton Hall, Congleton.
1901. ‡Arakawa, Minozi. Japanese Consulate, 84 Bishopsgate-street Within, E.C.
1900. §Arber, E. A. Newell, M.A., F.L.S. Trinity College, Cambridge.
1894. ‡Archibald, A. The Bank House, Ventnor.

Year of
Election.

1884. *Archibald, E. Douglas. 32 Shaftesbury-avenue, W.
1883. §Armistead, Richard. 17 Chambres-road, Southport.
1883. *Armistead, William. Hillcrest, Oaken, Wolverhampton.
1903. *ARMSTRONG, Dr. E. FRANKLAND. 55 Granville-park, Lewisham, S.E.
1873. *ARMSTRONG, HENRY E., Ph.D., LL.D., F.R.S. (Pres. B, 1885; Pres. L, 1902; Council 1899–1905), Professor of Chemistry in the City and Guilds of London Institute, Central Institution, Exhibition-road, S.W. 55 Granville-park, Lewisham, S.E.
1905. §Armstrong, John. Kamfersdam Mine, near Kimberley, Cape Colony.
1889. ‡Armstrong, Thomas John. 14 Hawthorn-terrace, Newcastle-upon-Tyne.
1905. §ARNOLD, J. O., Professor of Metallurgy in the University of Sheffield.
1893. ‡Arnold-Bemrose, H., M.A., F.G.S. 56 Friar-gate, Derby.
1901. ‡Arthur, Matthew. 78 Queen-street, Glasgow.
1904. ‡Arunáchalam, P. Ceylon Civil Service, Colombo, Ceylon.
1870. *Ash, Dr. T. Linnington. Penroses, Holsworthy, North Devon.
1903. *Ashby, Thomas, jun. The British School, Rome.
1874. ‡Ashe, Isaac, M.B. Dundrum, Co. Dublin.
1889. ‡Ashley, Howard M. Airedale, Ferrybridge, Yorkshire.
1887. ‡Ashton, Thomas Gair, M.A. 36 Charlotte-street, Manchester.
Ashworth, Henry. Turton, near Bolton.
1903. §Ashworth, J. H., D.Sc. 4 Cluny-terrace, Edinburgh.
1888. **Ashworth, J. Jackson. Kingston House, Didsbury, near Manchester.*
1890. ‡Ashworth, J. Reginald, D.Sc. 105 Freehold-street, Rochdale.
1887. ‡Ashworth, John Wallwork, F.G.S. Thorne Bank, Heaton Moor, Stockport.
1887. ‡Ashworth, Mrs. J. W. Thorne Bank, Heaton Moor, Stockport.
1905. §Askew, T. A. Main-road, Claremont, Cape Colony.
1875. *Aspland, W. Gaskell. 50 Park Hill-road, N.W.
1896. *Assheton, Richard, M.A., F.L.S. Grantchester, Cambridge.
1905. §Assheton, Mrs. Grantchester, Cambridge.
1903. ‡Atchison, Arthur F. T., B.Sc. Royal Engineering College, Cooper's Hill, Staines.
1896. §Atkin, George, J.P. Egerton Park, Rockferry.
1887. §Atkinson, Rev. C. Chetwynd, D.D. Ingestre, Ashton-on-Mersey.
1898. *Atkinson, E. Cuthbert. P.O. Box 846, Pretoria, South Africa.
1894. ‡Atkinson, George M. 28 St. Oswald's-road, S.W.
1894. *Atkinson, Harold W., M.A. Belvedere College, Pretoria, South Africa.
1881. ‡Atkinson, J. T. The Quay, Selby, Yorkshire.
1881. ‡ATKINSON, ROBERT WILLIAM, F.C.S. (Local Sec. 1891.) 44 Loudoun-square, Cardiff.
1894. §Atkinson, William. Erwood, Beckenham, Kent.
1863. *ATTFIELD, J., M.A., Ph.D., F.R.S., F.C.S. Ashlands, Watford, Herts.
1884. ‡Auchincloss, W. S. Atlantic Highlands, New Jersey, U.S.A.
1903. ‡AUSTIN, CHARLES E. 37 Cambridge-road, Southport.
1853. *AVEBURY, The Right Hon. Lord, D.C.L., F.R.S. (PRESIDENT, 1881; TRUSTEE, 1872– ; Pres. D, 1872; Council 1865–71.) High Elms, Farnborough, Kent.
1901. ‡*Aveling, T. C. 32 Bristol-street, Birmingham.*
1877. *AYRTON, W. E., F.R.S. (Pres. A, 1898; Council 1889–96), Professor of Electrical Engineering in the City and Guilds of London Institute, Central Institution, Exhibition-road, S.W., 41 Norfolk-square, W.

Year of Election

1884. ‡Baby, The Hon. G. Montreal, Canada.
1900. ‡BACCHUS, RAMSDEN (Local Sec. 1900). 15 Welbury-drive, Bradford.
1883. *Bach, Madame Henri. 19 Avenue Bosquet, Paris.
Backhouse, Edmund. Darlington.
1863. ‡Backhouse, T. W. West Hendon House, Sunderland.
1883. *Backhouse, W. A. St. John's, Wolsingham, R.S.O., Durham.
1887. *Bacon, Thomas Walter. Ramsden Hall, Billericay, Essex.
1887. ‡Baddeley, John. 1 Charlotte-street, Manchester.
1903. ‡Baden-Powell, Major B. 22 Prince's-gate, S.W.
1905. §Baikie, Robert. P. O. Box 36, Pretoria, South Africa.
1883. ‡Baildon, Dr. 42 Hoghton-street, Southport.
1892. ‡*Baildon, H. Bellyse. Duncliffe, Murrayfield, Edinburgh.*
1883. *Bailey, Charles, F.L.S. Atherstone House, North-drive, St. Anne's-on-the-Sea, Lancashire.
1893. ‡BAILEY, Colonel F., F.R.G.S. 7 Drummond-place, Edinburgh.
1870. ‡Bailey, Dr. Francis J. 51 Grove-street, Liverpool.
1887. *Bailey, G. H., D.Sc., Ph.D. Marple Cottage, Marple, Cheshire.
1905. *Bailey, Harry Percy. Care of India Rubber Co. Ltd., 213 West-street, Durban, Natal.
1899. ‡*Bailey, T. Lewis. Fernhill, Formby, Lancashire.*
1855. ‡Bailey, W. Horseley Fields Chemical Works, Wolverhampton.
1905. §Bailey, W. F. Land Commission, Dublin.
1894. *BAILY, FRANCIS GIBSON, M.A. 11 Ramsay-garden, Edinburgh.
1878. ‡BAILY, WALTER. 4 Roslyn-hill, Hampstead, N.W.
1897. §BAIN, JAMES. Public Library, Toronto, Canada.
1885. ‡Bain, William N. Collingwood, Pollokshields, Glasgow.
1905. §Baker, Sir Augustine. 56 Merrion-square, Dublin.
1882. *BAKER, Sir BENJAMIN, K.C.B., K.C.M.G., LL.D., D.Sc., F.R.S., M.Inst.C.E. (Pres. G, 1885; Council, 1889–96.) 2 Queen Square-place, Westminster, S.W.
1886. §Baker, Harry, F.I.C. Epworth House, Moughland-lane, Runcorn.
1898. ‡Baker, Herbert M. Wallcroft, Durdham Park, Clifton, Bristol.
1898. ‡Baker, Hiatt C. Mary-le-Port-street, Bristol.
1881. ‡Baker, Robert, M.D. The Retreat, York.
1875. ‡BAKER, W. PROCTOR. Bristol.
1881. ‡Baldwin, Rev. G. W. de Courcy, M.A. Warshill Vicarage, York.
1884. ‡Balete, Professor E. Polytechnic School, Montreal, Canada.
1904. ‡BALFOUR, The Right Hon. A. J., D.C.L., LL.D., M.P., F.R.S., Chancellor of the University of Edinburgh. Whittinghame, Prestonkirk, N.B.
1871. ‡Balfour, The Right Hon. G. W., M.P. 24 Addison-road, Kensington, W.
1894. §BALFOUR, HENRY, M.A. (Pres. H., 1904.) 11 Norham-gardens, Oxford.
1905. §Balfour, Mrs. H. 11 Norham-gardens, Oxford.
1875. ‡BALFOUR, ISAAC BAYLEY, M.A., D.Sc., M.D., F.R.S., F.R.S.E., F.L.S., (Pres. D, 1894; K, 1901), Professor of Botany in the University of Edinburgh. Inverleith House, Edinburgh.
1883. ‡Balfour, Mrs. I. Bayley. Inverleith House, Edinburgh.
1905. §Balfour, Mrs. J. Dawyck, Stobo, N.B.
1905. §Balfour, Lewis. 11 Norham-gardens, Oxford.
1905. §Balfour, Miss Vera B. Dawyck, Stobo, N.B.
1878. *Ball, Sir Charles Bent, M.D., Regius Professor of Surgery in the University of Dublin. 24 Merrion-square, Dublin.
1866. *BALL, Sir ROBERT STAWELL, LL.D., F.R.S., F.R.A.S. (Pres. A, 1887; Council 1884–90, 1892–94; Local Sec. 1878), Lowndean Professor of Astronomy and Geometry in the University of Cambridge. The Observatory, Cambridge.

Year of Election.

1883. *Ball, W. W. Rouse, M.A. Trinity College, Cambridge.
1905. §Ballantine, Rev. T. R. Tirmochree, Bloomfield, Belfast.
1886. ‡Ballantyne, J. W., M.B. 24 Melville-street, Edinburgh.
1869. ‡Bamber, Henry K., F.C.S. 5 Westminster-chambers, Victoria-street, Westminster, S.W.
1890. ‡Bamford, Professor Harry, B.Sc. 3 Albany-street, Glasgow.
1899. §Bampton, Mrs. 42 Marine-parade, Dover.
1882. ‡Bance, Colonel Edward, J.P. Oak Mount, Highfield, Southampton.
1905. §Banks, Miss Margaret Pierrepont. 10 Regent-terrace, Edinburgh.
1898. ‡Bannerman, W. Bruce, F.R.G.S., F.G.S. The Lindens, Sydenham-road, Croydon.
1866. ‡Barber, John. Long-row, Nottingham.
1890. *Barber-Starkey, W. J. S. Aldenham Park, Bridgnorth, Salop.
1861. *Barbour, George. Bolesworth Castle, Tattenhall, Chester.
1871. ‡Barclay, George. 17 Coates-crescent, Edinburgh.
1860. *Barclay, Robert. High Leigh, Hoddesden, Herts.
1887. *Barclay, Robert. Sedgley New Hall, Prestwich, Manchester.
1886. ‡Barclay, Thomas. 17 Bull-street, Birmingham.
1902. ‡Barcroft, H., D.L. The Glen, Newry, Co. Down.
1902. ‡Barcroft, Joseph, M.A., B.Sc. King's College, Cambridge.
1881. ‡Barfoot, William, J.P. Whelford-place, Leicester.
1882. ‡Barford, J. D. Above Bar, Southampton.
1904. §Barker, B. T. P. Fenswood, Long Ashton, Bristol.
1899 §Barker, John H., M.Inst.C.E. 2 Collingwood-street, Newcastle-on-Tyne.
1882. *Barker, Miss J. M. The Fox Covers, Bebington, Cheshire.
1898. §Barker, W. R. 106 Redland-road, Bristol.
1886. ‡Barling, Gilbert. 85 Edmund-street, Edgbaston, Birmingham.
1873. ‡Barlow, Crawford, B.A., M.Inst.C.E. Fordwich House, Sturry, Kent.
1889. ‡Barlow, H. W. L., M.A., M.B., F.C.S. The Park Hospital, Hither Green, S.E.
1883. ‡Barlow, J. J. 84 Cambridge-road, Southport.
1878. ‡Barlow, John, M.D., Professor of Physiology in St. Mungo's College, Glasgow.
1883. ‡Barlow, John R. Greenthorne, near Bolton.
1885. *Barlow, William, F.G.S. The Red House, Great Stanmore.
1905. §Barnard, Miss Annie T., M.B , B Sc. 32 Chenies-street Chambers, W.C.
1902. §Barnard, J. E. Lister Institute of Preventive Medicine, Chelsea-gardens, S.W.
1861. *Barnard, Major R. Cary, F.L.S. Bartlow, Leckhampton, Cheltenham.
1881. ‡Barnard, William, LL.B. 3 New-court, Lincoln's Inn, W.C.
1904. ‡Barnes, Rev. E. W., M.A., F.R.A.S. Trinity College, Cambridge.
1889. ‡Barnes, J. W. Bank, Durham.
1899. ‡Barnes, Robert. 9 Kildare-gardens, Bayswater, W.
1884. ‡Barnett, J. D. Port Hope, Ontario, Canada.
1901. ‡Barnett, P. A. Pietermaritzburg, South Africa.
1899. ‡Barnett, W. D. 41 Threadneedle-street, E.C.
1881. ‡Barr, Archibald, D.Sc., M.Inst.C.E., Professor of Civil Engineering in the University, Glasgow.
1890. ‡Barr, Frederick H. 4 South-parade, Leeds.
1859. ‡Barr, Lieut.-General. Apsleytoun, East Grinstead, Sussex.
1902. *Barr, Mark. The Cedars, Cowley, Middlesex.
1891. ‡Barrell, Frank R., M.A., Professor of Mathematics in University College, Bristol.
1904. ‡Barrett, Arthur. 6 Mortimer-road, Cambridge.

Year of Election.

1883. ‡Barrett, Mrs. J. C. Errismore, Birkdale, Southport.
1872. *BARRETT, W. F., F.R.S., F.R.S.E., M.R.I.A., Professor of Physics in the Royal College of Science, Dublin.
1883. ‡*Barrett, William Scott. Abbotsgate, Huyton, near Liverpool.*
1899. ‡BARRETT-HAMILTON, Captain G. E. H. Kilmannock House, Arthurstown, Waterford, Ireland.
1887. ‡Barrington, Miss Amy. 18 Bradley-gardens, West Ealing, W.
1874. *BARRINGTON, R. M., M.A., LL.B., F.L.S. Fassaroe, Bray, Co. Wicklow.
1874. *Barrington-Ward, Mark J., M.A., F.L.S., F.R.G.S., H.M. Inspector of Schools. Thorneloe Lodge, Worcester.
1866. ‡Barron, William. Elvaston Nurseries, Borrowash, Derby.
1893. *BARROW, GEORGE, F.G.S. Geological Survey Office, 28 Jermyn-street, S.W.
1886. ‡Barrow, George William. Baldraud, Lancaster.
1886. ‡Barrow, Richard Bradbury. Lawn House, 13 Ampton-road, Edgbaston, Birmingham.
1896. §Barrowman, James. Staneacre, Hamilton, N.B.
1886. ‡Barrows, Joseph, jun. Ferndale, Harborne-road, Edgbaston, Birmingham.
1858. ‡BARRY, Right Rev. ALFRED, D.D., D.C.L. The Cloisters, Windsor.
1883. ‡*Barry, Charles E. 1 Victoria-street, S.W.*
1881. ‡Barry, J. W. Duncombe-place, York.
1884. *Barstow, Miss Frances A. Garrow Hill, near York.
1890. *Barstow, J. J. Jackson. The Lodge, Weston-super-Mare.
1890. *Barstow, Mrs. The Lodge, Weston-super-Mare.
1892. ‡Bartholomew, John George, F.R.S.E., F.R.G.S. 12 Blacket-place, Edinburgh.
1858. *Bartholomew, William Hamond, M.Inst.C.E. Ridgeway House, Cumberland-road, Hyde Park, Leeds.
1884. ‡Bartlett, James Herbert. 148 Mansfield-street, Montreal, Canada.
1873. ‡Bartley, Sir G. C. T., K.C.B., M.P. St. Margaret's House, Victoria-street, S.W.
1892. ‡Barton, Miss. 4 Glenorchy-terrace, Mayfield, Edinburgh.
1893. ‡Barton, Edwin H., B.Sc. University College, Nottingham.
1852. ‡Barton, James, B.A., M.Inst.C.E. Farndreg, Dundalk.
1892. ‡Barton, William. 4 Glenorchy-terrace, Mayfield, Edinburgh.
1904. *Bartrum, C. O., B.Sc. 3 Holford-road, Hampstead, N.W.
1887. ‡Bartrum, John S. 13 Gay-street, Bath.
*Bashforth, Rev. Francis, B.D. Minting Vicarage, near Horncastle.
1888. *BASSET, A. B., M.A., F.R.S. Fledborough Hall, Holyport, Berkshire.
1891. ‡Bassett, A. B. Cheverell, Llandaff.
1866. *BASSETT, HENRY. 26 Belitha-villas, Barnsbury, N.
1889. ‡BASTABLE, Professor C. F., M.A., F.S.S. (Pres. F, 1894.) 6 Trevelyan-terrace, Rathgar, Co. Dublin.
1871. ‡BASTIAN, H. CHARLTON, M.A., M.D., F.R.S., F.L.S., Emeritus Professor of the Principles and Practice of Medicine in University College, London. 8A Manchester-square, W.
1883. ‡BATEMAN, Sir A. E., K.C.M.G., Controller-General Statistical Department, Board of Trade, 7 Whitehall-gardens, S.W.
1889. ‡Bates, C. J. Heddon, Wylam, Northumberland.
1884. ‡BATESON, WILLIAM, M.A., F.R.S. (Pres. D, 1904.) St. John's College, Cambridge.
1881. *BATHER, FRANCIS ARTHUR, M.A., D.Sc., F.G.S. British Museum (Natural History), S.W.
1863. §BAUERMAN, H., F.G.S. 14 Cavendish-road, Balham, S.W.
1904. †Baugh, J. H. Agar. 92 Hatton-garden, E.C.

Year of Election.

1867. ‡Baxter, Edward. Hazel Hall, Dundee.
1905. §Baxter, W. Duncan. P.O. Box 103, Cape Town.
1892. ‡Bayly, F. W. 8 Royal Mint, E.
1875. *Bayly, Robert. Torr Grove, near Plymouth.
1876. *Baynes, Robert E., M.A. Christ Church, Oxford.
1887. *Baynes, Mrs. R. E. 2 Norham-gardens, Oxford.
1883. *Bazley, Gardner S. Hatherop Castle, Fairford, Gloucestershire.
1905. *Bazley, Miss J. M. A. Winterdyne, Chine Crescent-road, Bournemouth.
Bazley, Sir Thomas Sebastian, Bart., M.A. Winterdyne, Chine Crescent-road, Bournemouth.
1886. ‡Beale, C. Calle Progress No. 83, Rosario de Santa Fé, Argentine Republic.
1886. ‡Beale, Charles G. Maple Bank, Edgbaston, Birmingham.
1860. *Beale, Lionel S., M.B., F.R.S. 6 Bentinck-street, Manchester-square, W.
1884. ‡Beamish, G. H.M. Prison, Liverpool.
1872. ‡Beanes, Edward, F.C.S. Moatlands, Paddock Wood, Brenchley, Kent.
1905. §Beard, Henry. Highwick, Kenilworth, Cape Colony.
1883. ‡Beard, Mrs. Oxford.
1889. §Beare, Professor T. Hudson, B.Sc., F.R.S.E., M.Inst.C.E. The University, Edinburgh.
1905. §Beare, Mrs. T. Hudson. 10 Regent-terrace, Edinburgh.
1904. §Beasley, H. C. 25a Prince Alfred-road, Wavertree, Liverpool.
1905. §Beattie, Professor J. C., D.Sc., F.R.S.E. South African College, Cape Town.
1889. ‡Beattie, John. 5 Summerhill-grove, Newcastle-upon-Tyne.
1902. ‡Beatty, H. M., LL.D. Ballymena, Co. Antrim.
1855. *Beaufort, W. Morris, F.R.A.S., F.R.G.S., F.R.M.S., F.S.S. 18 Piccadilly, W.
1886. ‡Beaugrand, M. H. Montreal, Canada.
1900. ‡Beaumont, Professor Roberts, M.I.Mech.E. The University, Leeds.
1861. *Beaumont, Rev. Thomas George. Oakley Lodge, Leamington.
1887. *Beaumont, W. J. The Laboratory, Citadel Hill, Plymouth.
1885. *Beaumont, W. W., M.Inst.C.E. Outer Temple, 222 Strand, W.C.
1896. ‡Beazer, C. Hindley, near Wigan.
1887. *Beckett, John Hampden. Corbar Hall, Buxton, Derbyshire.
1904. §Beckit, H. O. The Schoolhouse, Whitchurch, Salop.
1885. ‡Beddard, Frank E., M.A., F.R.S., F.Z.S., Prosector to the Zoological Society of London, Regent's Park, N.W.
1870. ‡Beddoe, John, M.D., F.R.S. (Council, 1870–75.) The Chantry, Bradford-on-Avon.
1890. ‡Bedford, James E., F.G.S. Shireoak-road, Leeds.
1904. *Bedford, T. G., M.A. 9 Victoria-street, Cambridge.
1891. ‡Bedlington, Richard. Gadlys House, Aberdare.
1878. ‡Bedson, P. Phillips, D.Sc., F.C.S. (Local Sec. 1889), Professor of Chemistry in the College of Physical Science, Newcastle-upon-Tyne.
1884. ‡Beers, W. G., M.D. 34 Beaver Hall-terrace, Montreal, Canada.
1901. *Beilby, G. T. (Pres. B, 1905.) 11 University-gardens, Glasgow.
1905. §Beilby, Hubert. 11 University-gardens, Glasgow.
1874. ‡Belcher, Richard Boswell. Blockley, Worcestershire.
1891. *Belinfante, L. L., M.Sc., Assist.-Sec. G.S. Burlington House, W.
1892. ‡Bell, A. Beatson. 17 Lansdowne-crescent, Edinburgh.
1871. ‡Bell, Charles B. 6 Spring-bank, Hull.
1884 ‡Bell, Charles Napier. Winnipeg, Canada.
1894. ‡Bell, F. Jeffrey, M.A., F.Z.S. British Museum, S.W.

Year of Election.

Bell, Frederick John. Woodlands, near Maldon, Essex.
1900. *Bell, H. Wilkinson. Holmehurst, Rawdon, near Leeds.
1875. ‡BELL, JAMES, C.B., D.Sc., Ph.D., F.R.S. 52 Cromwell-road, Hove, Brighton.
1896. ‡Bell, James. Care of the Liverpool Steam Tug Co., Limited, Chapel-chambers, 28 Chapel-street, Liverpool.
1871. *BELL, J. CARTER, F.C.S. The Cliff, Higher Broughton, Manchester.
1883. *Bell, John Henry. 102 Leyland-road, Southport.
1864. ‡Bell, R. Queen's College, Kingston, Canada.
1905. §Bell, W. H. S. P.O. Box 4284, Johannesburg.
1888. *Bell, Walter George, M.A. Trinity Hall, Cambridge.
1904. ‡Bellars, A. E. Magdalene College, Cambridge.
1893. ‡BELPER, The Right Hon. Lord, LL.M. Kingston, Nottinghamshire.
1904. *Bemrose, H. Arnold. Ash Tree House, Derby.
1884. ‡Bemrose, Joseph. 15 Plateau-street, Montreal, Canada.
1905. §Bender, Rev. A. P., M.A. Synagogue House, Cape Town.
1885. ‡BENHAM, WILLIAM BLAXLAND, D.Sc., Professor of Biology in the University of Otago, New Zealand.
1896. ‡Bennett, George W. West Ridge, Oxton, Cheshire.
1881. ‡Bennett, John Ryan. 3 Upper Belgrave-road, Clifton, Bristol.
1883. *Bennett, Laurence Henry. The Elms, Paignton, South Devon.
1901. ‡Bennett, Professor Peter. 6 Kelvinhaugh-street, Sandyford, Glasgow.
1896. ‡Bennett, Richard. 19 Brunswick-street, Liverpool.
1881. ‡Bennett, Rev. S. H., M.A. St. Mary's Vicarage, Bishopshill Junior, York.
1905. §Benson, Arthur H., M.A., F.R.C.S. 42 Fitzwilliam-square, Dublin.
1905. §Benson, Mrs. A. H. 42 Fitzwilliam-square, Dublin.
1903. §Benson, D. E. Queenwood, 18 Lansdowne-road, Southport.
1889. ‡Benson, John G. 12 Grey-street, Newcastle-upon-Tyne.
1901. *Benson, Miss Margaret J., D.Sc. Royal Holloway College, Egham.
1887. *Benson, Mrs. W. J. Care of W. J. Benson, Esq., Standard Bank, Johannesburg, Transvaal.
1863. ‡Benson, William. Fourstones Court, Newcastle-upon-Tyne.
1898. *Bent, Mrs. Theodore. 13 Great Cumberland-place, W.
1884. ‡Bentham, William. 724 Sherbrooke-street, Montreal, Canada.
1904. ‡Bentley, B. H. University College, Sheffield.
1905. §Bentley, F. W. Rein Wood, Huddersfield.
1905. *Bentley, W. C. Rein Wood, Huddersfield.
1897. ‡Bently, R. R. 97 Dowling-avenue, Toronto, Canada.
1896. *Bergin, William, M.A., Professor of Natural Philosophy in Queen's College, Cork.
1901. ‡Bergins, Walter L. 8 Marlborough-terrace, Glasgow.
1894. §Berkeley, The Right Hon. the Earl of, F.G.S. Foxcombe, Boarshill, near Abingdon.
1863. ‡Berkley, C. Marley Hill, Gateshead, Durham.
1905. §Bernacchi, L. C., F.R.G.S. National Liberal Club, Whitehall-place, S.W.
1886. ‡Bernard, W. Leigh. Calgary, Canada.
1898. §Berridge, Miss C. E. 18 Edridge-road, Croydon.
1894. §Berridge, Douglas, M.A., F.C.S. The College, Malvern.
1904. §Berry, R. A. 5 St. Mary's-passage, Cambridge.
1905. §Bertrand, Captain Alfred. Champel, Geneva.
1862. ‡BESANT, WILLIAM HENRY, M.A., D.Sc., F.R.S. St. John's College, Cambridge.
1882. *Bessemer, Henry. Moorlands, Bitterne, Southampton.

Year of Election.

1890. ‡*Best, William Woodham.* 31 *Lyddon-terrace, Leeds.*
1880. *Bevan, Rev. James Oliver, M.A., F.S.A., F.G.S. Chillenden Rectory, Dover.
1904. *Bevan, P. V., M.A. Garden-walk, Chesterton, Cambridge.
1885. ‡Beveridge, R. Beath Villa, Ferryhill, Aberdeen.
1884. *Beverley, Michael, M.D. 54 Prince of Wales-road, Norwich.
1903. ‡Bickerdike, C. F. 1 Boveney-road, Honor Oak Park, S.E.
1888. *Bidder, George Parker. Savile Club, Piccadilly, W.
1885. *Bidwell, Shelford, Sc.D., LL.B., F.R.S. Beechmead, Oatlands Chase, Weybridge.
1904. §Bigg-Wither, Colonel A. C. Tilthams, Godalming, Surrey.
1882. §Biggs, C. H. W., F.C.S. Glebe Lodge, Champion Hill, S.E.
1898. ‡Billington, Charles. Studleigh, Longport, Staffordshire.
1901. *Bilsland, William, J.P. 28 Park-circus, Glasgow.
1886. ‡Bindloss, G. F. Carnforth, Brondesbury Park, N.W.
1887. *Bindloss, James B. Elm Bank, Buxton.
1884. *Bingham, Colonel Sir John E., Bart. West Lea, Ranmoor, Sheffield.
1881. ‡Binnie, Sir Alexander R., M.Inst.C.E., F.G.S. (Pres. G, 1900.) 77 Ladbroke-grove, W.
1900. ‡Bird, F. J. Norton House, Midsomer Norton, Bath.
1880. ‡Bird, Henry, F.C.S. South Down House, Millbrook, near Devonport.
1888. *Birley, Miss Caroline. 14 Brunswick-gardens, Kensington, W.
1887. *Birley, H. K. Penrhyn, Irlams o' th' Height, Manchester.
1904. §Bishop, A. W. Edwinstowe, Chaucer-road, Cambridge.
1894. ‡Bisset, James, F.R.S.E. 9 Greenhill-park, Edinburgh.
1885. ‡Bissett, J. P. Wyndem, Banchory, N.B.
1886. *Bixby, Colonel W. H. Room 508, Federal-building, Chicago, U.S.A.
1905. §Black, Alexander. 31 Albert-road, Woodstock, Cape Colony.
1901. ‡Black, John Albert. Lagarie-row, Helensburgh, N.B.
1889. ‡Black, W. 1 Lovaine-place, Newcastle-upon-Tyne.
1881. ‡Black, Surgeon-Major William Galt, F.R.C.S.E. Caledonian United Service Club, Edinburgh.
1901. §Black, W. P. M. 136 Wellington-street, Glasgow.
1876. ‡Blackburn, Hugh, M.A. Roshven, Fort William, N.B.
1884. ‡Blackburn, Robert. New Edinburgh, Ontario, Canada.
1900. ‡Blackburn, W. Owen. 3 Mount Royd, Bradford.
1877. ‡Blackie, J. Alexander. 17 Stanhope-street, Glasgow.
1855. *Blackie, W. G., Ph.D., F.R.G.S. (Local Sec. 1876). 1 Belhaven-terrace, Kelvinside, Glasgow.
1884. ‡Blacklock, Frederick W. 25 St. Famille-street, Montreal, Canada.
1903. *Blackman, F. F., M.A., D.Sc. St. John's College, Cambridge.
1886. ‡Blaikie, John, F.L.S. The Bridge House, Newcastle, Staffordshire.
1895. ‡Blaikie, W. B. 6 Belgrave-crescent, Edinburgh.
1883. ‡Blair, Mrs. Oakshaw, Paisley.
1892. ‡Blair, Alexander. 35 Moray-place, Edinburgh.
1892. ‡Blair, John. 9 Ettrick-road, Edinburgh.
1883. *Blake, Rev. J. F., M.A., F.G.S. 35 Harlesden-gardens, N.W.
1902. ‡Blake, Robert F., F.I.C. 66 Malone-avenue, Belfast.
1891. ‡Blakesley, Thomas H., M.A., M.Inst.C.E. Royal Naval College, Greenwich, S.E.
1894. ‡Blakiston, Rev. C. D. Exwick Vicarage, Exeter.
1900. *Blamires, Joseph. Bradley Lodge, Huddersfield.
1905. §Blamires, Mrs. Bradley Lodge, Huddersfield.

Year of Election.

1881. ‡*Blamires, Thomas H. Close Hill, Lockwood, near Huddersfield.*
1895. ‡*Blamires, William. Oak House, Taylor Hill, Huddersfield.*
1904. ‡Blanc, Dr. Gian Alberto. Istituto Fisico, Rome.
1884. *Blandy, William Charles, M.A. 1 Friar-street, Reading.
1887. *Bles, A. J. S. Palm House, Park-lane, Higher Broughton, Manchester.
1887. *Bles, Edward J., M.A., B.Sc. The University, Glasgow.
1887. ‡Bles, Marcus S. The Beeches, Broughton Park, Manchester.
1884. *Blish, William G. Niles, Michigan, U.S.A.
1902. ‡Blount, Bertram, F.I.C. 76 & 78 York-street, Westminster, S.W.
1888. ‡Bloxsom, Martin, B.A., Assoc.M.Inst.C.E. Hazelwood, Crumpsall Green, Manchester.
Blyth, B. Hall. 135 George-street, Edinburgh.
1885. ‡BLYTH, JAMES, M.A., F.R.S.E., Professor of Natural Philosophy in Anderson's College, Glasgow.
1867. *Blyth-Martin, W. Y. Blyth House, Newport, Fife.
1887. ‡*Blythe, William S. 65 Mosley-street, Manchester.*
1901. §BLYTHSWOOD, The Right Hon. Lord, LL.D. Blythswood, Renfrew.
1870. ‡Boardman, Edward. Oak House, Eaton, Norwich.
1887. *Boddington, Henry. Pownall Hall, Wilmslow, Manchester.
1900. ‡BODINGTON, Principal N., Litt.D. Yorkshire College, Leeds.
1889. ‡Bodmer, G. R., Assoc.M.Inst.C.E. 53 Victoria-street, S.W.
1884. ‡Body, Rev. C. W. E., M.A. Trinity College, Toronto, Canada.
1900. ‡Boileau, Lieut.-Colonel A. C. T., R.A. Royal Artillery Institution, Woolwich.
1887. *Boissevain, Gideon Maria. 4 Tesselschade-straat, Amsterdam.
1898. §BOLTON, H., F.R.S.E. The Museum, Queen's-road, Bristol.
1898. ‡Bolton, J. W. Baldwin-street, Bristol.
1894. §BOLTON, JOHN. 15 Cranley-gardens, Highgate, N.
1898. *BONAR, JAMES, M.A., LL.D. (Pres. F, 1898; Council 1899–1905.) Civil Service Commission, Burlington-gardens, W.
1883. ‡Bonney, Frederic, F.R.G.S. Colton House, Rugeley, Staffordshire.
1871. *BONNEY, Rev. THOMAS GEORGE, D.Sc., LL.D., F.R.S., F.S.A., F.G.S. (SECRETARY, 1881–85; Pres. C, 1886.) 9 Scroope-terrace, Cambridge.
1888. ‡Boon, William. Coventry.
1893. ‡Boot, Jesse. Carlyle House, 18 Burns-street, Nottingham.
1890. *BOOTH, Right Hon. CHARLES, D.Sc., F.R.S., F.S.S. 24 Great Cumberland-place, W.
1883. ‡Booth, James. Hazelhurst, Turton.
1876. ‡Booth, Rev. William H. St. Paul's Rectory, Old Charlton, Kent.
1883. ‡Boothroyd, Benjamin. Weston-super-Mare.
1901. *Boothroyd, Herbert E., M.A., B.Sc. Sidney Sussex College, Cambridge.
1900. ‡*Borchgrevink, C. E. Lindfield, Sussex.*
1882. §BORNS, HENRY, Ph.D., F.C.S. 5 Sutton Court-road, Chiswick, W.
1901. ‡Borradaile, L. A., M.A. Selwyn College, Cambridge.
1876. *BOSANQUET, R. H. M., M.A., F.R.S., F.R.A.S. Castillo Zamora, Realejo-Alto, Teneriffe.
1903. §Bosanquet, Robert C. Barmoor Castle, Beal, Northumberland.
1896. ‡Bose, Professor J. C., C.I.E., M.A., D.Sc. Calcutta, India.
1881. §BOTHAMLEY, CHARLES H., F.I.C., F.C.S., Director of Technical Instruction, Somerset County Education Committee. Tanglewood, Southside, Weston-super-Mare.
1872. ‡Bottle, Alexander. 4 Godwyne-road, Dover.

Year of Election.

1868. ‡Bottle, J. T. 28 Nelson-road, Great Yarmouth.
1887. ‡Bottomley, James, D.Sc., B.A. 220 Lower Broughton-road, Manchester.
1871. *Bottomley, James Thomson, M.A., LL.D., D.Sc., F.R.S., F.R.S.E., F.C.S. 13 University-gardens, Glasgow.
1884. *Bottomley, Mrs. 13 University-gardens, Glasgow.
1892. ‡Bottomley, W. B., B.A., Professor of Botany in King's College, W.C.
1876. ‡Bottomley, William, jun. 15 University-gardens, Glasgow.
1905. §Boulenger, G. A., F.R.S. (Pres. D, 1905). 8 Courtfield-road, S.W.
1905. §Boulenger, Mrs. 8 Courtfield-road, S.W.
1890. ‡Boulnois, Henry Percy, M.Inst.C.E. 44 Campden House Court, Kensington, W.
1903. §Boulton, W. S., B.Sc., F.G.S., Professor of Geology in University College, Cardiff. 2 Kymin-terrace, Penarth.
1883. ‡Bourdas, Isaiah. Dunoon House, Clapham Common, S.W.
1883. ‡Bourne, A. G., D.Sc., F.R.S., F.L.S., Professor of Biology in the Presidency College, Madras.
1893. *Bourne, G. C., M.A., D.Sc., F.L.S. (Council, 1903- ; Local Sec. 1894.) Savile House, Mansfield-road, Oxford.
1890. ‡Bousfield, C. E. 55 Clarendon-road, Leeds.
1904. *Bousfield, E. G. P. Hungate Mills, York.
1902. ‡Bousfield, Sir William. 20 Hyde Park-gate, W.
1898. ‡Bovey, Edward P., jun. Clifton-grove, Torquay.
1884. ‡Bovey, Henry T., M.A., F.R.S., M.Inst.C.E., Professor of Civil Engineering and Applied Mechanics in McGill University, Montreal. Ontario-avenue, Montreal, Canada.
1888. ‡Bowden, Rev. G. New Kingswood School, Lansdown, Bath.
1881. *Bower, F. O., D.Sc., F.R.S., F.R.S.E., F.L.S. (Pres. K, 1898; Council 1900-), Regius Professor of Botany in the University of Glasgow.
1898. *Bowker, Arthur Frank, F.R.G.S., F.G.S. Seal, Sevenoaks.
1898. §Bowley, A. L., M.A. Lynwood, Southern Hill, Reading.
1880. ‡Bowly, Christopher. Cirencester.
1887. ‡Bowly, Mrs. Christopher. Cirencester.
1899. *Bowman, Herbert Lister, M.A. Greenham Common, Newbury.
1899. *Bowman, John Herbert. Greenham Common, Newbury.
1887. §Box, Alfred Marshall. Care of Messrs. Cooper, Box, & Co., 69 Aldermanbury, E.C.
1895. *Boyce, Rubert, M.B., F.R.S., Professor of Pathology in the University of Liverpool.
1901. ‡Boyd, David T. Rhinsdale, Ballieston, Lanark.
1884. *Boyle, R. Vicars, C.S.I. 3 Stanhope-terrace, Hyde Park, W.
1892. §Boys, Charles Vernon, F.R.S. (Pres. A, 1903; Council, 1893-99, 1905- .) 27 The Grove, Boltons, S.W.
1905. §Boys, Mrs. C. Vernon. 27 The Grove, Boltons, S.W.
1872. *Brabrook, Sir E. W., C.B., F.S.A. (Pres. H, 1898; Pres. F, 1903; Council, 1903-). 178 Bedford-hill, Balham, S.W.
1869. *Braby, Frederick, F.G.S., F.C.S. Bushey Lodge, Teddington, Middlesex.
1894. *Braby, Ivon. Bushey Lodge, Teddington, Middlesex.
1905. §Bradford, Wager. P.O. Box 1056, Johannesburg.
1893. §Bradley, F. L. Ingleside, Malvern Wells.
1904. *Bradley, Gustav. Town Hall, Leigh, Lancashire.
1899. *Bradley, J. W., Assoc.M.Inst.C.E., F.G.S. Westminster City Hall, Charing Cross-road, W.C.
1903. *Bradley, O. Charnock, D.Sc., M.B., F.R.S.E. Royal Veterinary College, Edinburgh.

Year of
Election.

1892. ‡Bradshaw, W. Carisbrooke House, The Park, Nottingham.
1863. ‡BRADY, GEORGE S., M.D., LL.D., F.R.S., Professor of Natural History in the Durham College of Science, Newcastle-on-Tyne. 2 Mowbray-villas, Sunderland.
1880. *Brady, Rev. Nicholas, M.A. Rainham Hall, Rainham, S.O., Essex.
1888. §Braikenridge, W. J., J.P. 16 Royal-crescent, Bath.
1905. §Brakhan, A. P.O. Box 4249, Johannesburg.
1898. ‡Bramble, Lieut.-Colonel James R., F.S.A. Seafield, Weston-super-Mare.
1867. ‡Brand, William. Milnefield, Dundee.
1885. *Bratby, William, J.P. Alton Lodge, Hale, Bowdon, Cheshire.
1902. ‡Braun, Henry C. 1 North-street, King's Cross, N.
1905. §Brausewetter, Miss. Roedean School, near Brighton.
1890. *Bray, George. Belmont, Wood-lane, Headingley, Leeds.
1905. §Bremner, R. S. Westminster-chambers, Dale-street, Liverpool.
1905. §Bremner, Stanley. Westminster-chambers, Dale-street, Liverpool.
1902. *Brereton, Cloudesley. Briningham House, Briningham, S.O., Norfolk.
1898. §Brereton, Cuthbert A., M.Inst.C.E. 21 Delahay-street, S.W.
1882. §Bretherton, C. E. 26 Palace-mansions, Addison Bridge, W.
1866. ‡Brettell, Thomas. Dudley.
1905. §Brewis, E. 27 Winchelsea-road, Tottenham, N.
1886. §BRIDGE, T. W., M.A., D.Sc., F.R.S., Professor of Zoology in the University of Birmingham.
1887. ‡Brierley, John, J.P. The Clough, Whitefield, Manchester.
1886. ‡Brierley, Leonard. Somerset-road, Edgbaston, Birmingham.
1879. ‡Brierley, Morgan. Denshaw House, Saddleworth.
1870. *BRIGG, JOHN, M.P. Kildwick Hall, Keighley, Yorkshire.
1890. ‡Brigg, W. A. Kildwick Hall, Keighley, Yorkshire.
1904. *Briggs, William, M.A., LL.D., F.R.A.S. Burlington House, Cambridge.
1893. ‡Bright, Joseph. Western-terrace, The Park, Nottingham.
1905. §Brill, J., Litt.D. Grey College, Bloemfontein, South Africa.
1893. ‡Briscoe, Albert E., B.Sc., A.R.C.Sc. Municipal Technical Institute, Romford-road, West Ham, E.
1904. §Briscoe, J. J. Bourn Hall, Bourn, Cambridge.
1905. §Briscoe, Miss. Bourn Hall, Bourn, near Cambridge.
1884. ‡Brisette, M. H. 424 St. Paul-street, Montreal, Canada.
1898. ‡BRISTOL, The Right Rev. G. F. BROWNE, D.D., Lord Bishop of. 17 The Avenue, Clifton, Bristol.
1879. *BRITTAIN, W. H., J.P., F.R.G.S. Storth Oaks, Sheffield.
1878. ‡Britten, James, F.L.S. Department of Botany, British Museum, S.W.
1884. *Brittle, John R., M.Inst.C.E., F.R.S.E. 9 Vanbrugh-hill, Blackheath, S.E.
1899. ‡Broadwood, Miss Bertha M. Pleystowe, Capel, Surrey.
1899. ‡Broadwood, James H. E. Pleystowe, Capel, Surrey.
1905. *Broadwood, Brigadier-General R. G. The Deodars, Bloemfontein, South Africa.
1905. §Brock, Dr. B. G. P.O. Box 216, Germiston, Transvaal.
1897. ‡Brock, W. R. Toronto.
1896. *Brocklehurst, S. Olinda, Sefton Park, Liverpool.
1883. *Brodie, David, M.D. Slingsby Villa, Regent's Park-road, N.
1901. ‡Brodie, T. G., M.D., F.R.S. 4 Lancaster-terrace, Regent's Park, N.W.
1884. ‡Brodie, William, M.D. 64 Lafayette-avenue, Detroit, Michigan, U.S.A.

Year of Election.

1901. ‡Brodie, W. Brodie, M.D., F.R.S.E. 28 Hamilton Park-terrace, Hillhead, Glasgow.
1883. *Brodie-Hall, Miss W. L. 5 Devonshire-place, Eastbourne.
1905. §Brodigan, C. B. Brakpan Mines, Johannesburg.
1903. ‡BRODRICK, HAROLD, M.A. (Local Sec., 1903.) 7 Aughton-road, Birkdale, Southport.
1904. ‡Bromich, T. J. I'A., M.A., Professor of Mathematics in Queen's College, Galway.
1881. ‡Brook, Robert G. Wolverhampton House, St. Helens, Lancashire.
1905. *Brooke, Geoffrey. Christ Church Vicarage, Mirfield, S.O., Yorkshire.
1864. *Brooke, Ven. Archdeacon J. Ingham. The Vicarage, Halifax.
1887. §Brooks, James Howard. Elm Hirst, Wilmslow, near Manchester.
1863. ‡Brooks, John Crosse. 14 Lovaine-place, Newcastle-on-Tyne.
1887. ‡Brooks, S. H. Slade House, Levenshulme, Manchester.
1883. *Brotherton, E. A., M.P. Arthington Hall, Wharfedale, viâ Leeds.
1901. §Brough, Bennett H., F.I.C., F.G.S. 28 Victoria-street, S.W.
1883. *Brough, Mrs. Charles S. 4 Eastern Villas-road, Southsea.
1886. ‡Brough, Joseph, LL.D., Professor of Logic and Philosophy in University College, Aberystwyth.
1905. §Brown, A. R. Trinity College, Cambridge.
1896. ‡Brown, A. T. The Nunnery, St. Michael's Hamlet, Liverpool.
1863. *BROWN, ALEXANDER CRUM, M.D., LL.D., F.R.S., F.R.S.E., V.P.C.S. (Pres. B, 1874; Local Sec. 1871), Professor of Chemistry in the University of Edinburgh. 8 Belgrave-crescent, Edinburgh.
1892. ‡Brown, Andrew, M.Inst.C.E. Messrs. Wm. Simons & Co., Renfrew, near Glasgow.
1867. ‡Brown, Sir Charles Gage, M.D., K.C.M.G. 88 Sloane-street, S.W.
1855. ‡Brown, Colin. 192 Hope-street, Glasgow.
1871. ‡Brown, David. Willowbrae House, Midlothian.
1863. **Brown, Rev. Dixon. Unthank Hall, Haltwhistle, Carlisle.*
1883. †Brown, Mrs. Ellen F. Campbell. 27 Abercromby-square, Liverpool.
1905. §Brown, Ernest William, M.A., D.Sc., F.R.S., Professor of Mathematics in Haverford College, Haverford, Pennsylvania, U.S.A.
1903. ‡Brown, F. W. 6 Rawlinson-road, Southport.
1881. ‡Brown, Frederick D. 26 St. Giles's-street, Oxford.
1807. §BROWN, HORACE T., LL.D., F.R.S., F.G.S. (Pres. B, 1899; Council, 1904– .) 52 Nevern-square, S.W.
1870. *BROWN, J. CAMPBELL, D.Sc., F.C.S., Professor of Chemistry in the University of Liverpool.
1905. §Brown, J. Ellis. Durban, Natal.
1894. ‡*Brown, J. H. 6 Cambridge-road, Brighton.*
1876. §BROWN, JOHN, F.R.S. (Local Sec. 1902.) Longhurst, Dunmurry, Belfast.
1881. *Brown, John, M.D. 2 Glebe-terrace, Rondebosch, Cape Colony.
1882. **Brown, John. 7 Second-avenue, Nottingham.*
1895. *Brown, John Charles. Burlington-road, Sherwood, Nottingham.
1905. §Brown, John S. Longhurst, Dunmurry, Belfast.
1905. §Brown, L. Clifford. Beyer's Kloof, Klapmuts, Cape Colony.
1882. *Brown, Mrs. Mary. 2 Glebe-terrace, Rondebosch, Cape Colony.
1898. §Brown, Nicol, F.G.S. 4 The Grove, Highgate, N.
1897. ‡Brown, Price, M.B. 37 Carlton-street, Toronto, Canada.
1886. ‡Brown, R., R.N. Laurel Bank, Barnhill, Perth.

Year of Election.

1905. §Brown, R. C. Strathyre, Troyville, Transvaal.
1901. ‡Brown, R. N. R., B.Sc. University College, Dundee.
1863. ‡Brown, Ralph. Lambton's Bank, Newcastle-upon-Tyne.
1897. ‡Brown, Richard. Jarvis-street, Toronto, Canada.
1896. ‡Brown, Stewart H. Quarry Bank, Allerton, Liverpool.
1891. §BROWN, T. FORSTER, M.Inst.C.E. (Pres. G, 1891.) Springfort, Stoke Bishop, Bristol.
1885. ‡Brown, W. A. The Court House, Aberdeen.
1884. ‡Brown, William George. Ivy, Albemarle Co., Virginia, U.S.A.
1863. ‡Browne, Sir Benjamin Chapman, M.Inst.C.E. Westacres, Newcastle-upon-Tyne.
1900. *Browne, Frank Balfour, M.A., F.R.S.E., F.Z.S. Sutton Broad Laboratory, Catfield, Great Yarmouth.
1895. *Browne, H. T. Doughty. 10 Hyde Park-terrace, W.
1879. ‡BROWNE, Sir J. CRICHTON, M.D., LL.D., F.R.S., F.R.S.E. 61 Carlisle-place-mansions, Victoria-street, S.W.
1905. *Browne, James Stark, F.R.A.S. The Red House, Mount-avenue, Ealing, W.
1891. ‡BROWNE, MONTAGU, F.G.S. Town Museum, Leicester.
1872. ‡Browne, R. Mackley, F.G.S. Redcot, Bradbourne, Sevenoaks, Kent.
1862. *Browne, Robert Clayton, M.A. Browne's Hill, Carlow, Ireland.
1865. ‡Browning, John, F.R.A.S. 78 Strand, W.C.
1883. ‡Browning, Oscar, M.A. King's College, Cambridge.
1905. §BRUCE, Colonel DAVID, C.B., M.B., F.R.S. (Pres. I, 1905.) War Office, 68 Victoria-street, S.W.
1905. §Bruce, Mrs. 3P Artillery-mansions, Victoria-street, S.W.
1892. ‡Bruce, James. 10 Hill-street, Edinburgh.
1901. ‡Bruce, John. Inverallan, Helensburgh.
1893. †Bruce, William S. 11 Mount Pleasant, Joppa, Edinburgh.
1902. ‡*Bruce-Kingsmill, Captain J., R.A. Royal Arsenal, Woolwich.*
1900. *Brumm, Charles. Lismara, Grosvenor-road, Birkdale, Southport.
1905. §Brummer, N. J. Blommertein, Three Anchor Bay, Cape Colony.
1875. ‡Brunlees, John, M.Inst.C.E. 12 Victoria-street, Westminster, S.W.
1896. *Brunner, Sir J. T., Bart., M.P. Druid's Cross, Wavertree, Liverpool.
1868. ‡BRUNTON, Sir T. LAUDER, M.D., D.Sc., F.R.S. 10 Stratford-place, Cavendish-square, W.
1905. §Brunton, Lady. 10 Stratford-place, Cavendish-square, W.
1897. *Brush, Charles F. Cleveland, Ohio, U.S.A.
1878. ‡Brutton, Joseph. Yeovil.
1886. *BRYAN, G. H., D.Sc., F.R.S., Professor of Mathematics in University College, Bangor.
1894. ‡Bryan, Mrs. R. P. Plas Gwyn, Bangor.
1884. ‡BRYCE, Rev. Professor GEORGE. Winnipeg, Canada.
1897. ‡BRYCE, Right Hon. JAMES, D.C.L., M.P., F.R.S. 54 Portland-place, W.
1901. ‡Bryce, Thomas H. 2 Granby-terrace, Hillhead, Glasgow.
1894. ‡Brydone, R. M. Petworth, Sussex.
1902. *Bubb, Miss E. Maude. Ullenwood, near Cheltenham.
1890. §Bubb, Henry. Ullenwood, near Cheltenham.
1871. §BUCHAN, ALEXANDER, M.A., LL.D., F.R.S., F.R.S.E., Sec. Scottish Meteorological Society. 2 Dean-terrace, Edinburgh.
1867. ‡Buchan, Thomas. Strawberry Bank, Dundee.
1902. *Buchanan, Miss Florence, D.Sc. University Museum, Oxford.
1901. ‡Buchanan, James, M.D. 12 Hamilton-drive, Maxwell Park, Glasgow.
1905. §Buchanan, Right Hon. Sir John. Clareinch, Claremont, Cape Town.
1881. *Buchanan, John H., M.D. Sowerby, Thirsk.

Year of Election.

1871. ‡BUCHANAN, JOHN YOUNG, M.A., F.R.S., F.R.S.E., F.R.G.S., F.C.S. Christ's College, Cambridge.
1883. ‡Buckland, Miss A. W. 5 Beaumont-crescent, West Kensington, W.
1886. *Buckle, Edmund W. 23 Bedford-row, W.C.
1884. *Buckmaster, Charles Alexander, M.A., F.C.S. 16 Heathfield-road, Mill Hill Park, W.
1904. §Buckwell, J. C. North Gate House, Pavilion, Brighton.
1887. ‡Budenberg, C. F., B.Sc. Buckau Villa, Demesne-road, Whalley Range, Manchester.
1875. ‡Budgett, Samuel. Penryn, Beckenham, Kent.
1893. §BULLEID, ARTHUR, F.S.A. The Old Vicarage, Midsomer Norton, Bath.
1903. *Bullen, Rev. R. Ashington. The Locks, Hurstpierpoint, Sussex.
1871. ‡Bulloch, Matthew. 48 Prince's-gate, S.W.
1883. ‡Bulpit, Rev. W. T. Crossens Rectory, Southport.
1895. ‡Bunte, Dr. Hans. Karlsruhe, Baden.
1905. §Burbury, Mrs. A. A. 17 Upper Phillimore-gardens, W.
1905. §Burbury, Miss A. D. 17 Upper Phillimore-gardens, W.
1886. §BURBURY, S. H., M.A., F.R.S. 1 New-square, Lincoln's Inn, W.C.
1869. ‡Burdett-Coutts, Baroness. 1 Stratton-street, Piccadilly, W.
1881. ‡Burdett-Coutts, William Lehmann, M.P. 1 Stratton-street, Piccadilly, W.
1905. §Burdon, E. R., B.A. Devana-terrace, Huntingdon-road, Cambridge.
1891. ‡Burge, Very Rev. T. A. Ampleforth Cottage, near York.
1894. ‡BURKE, JOHN B. B. Trinity College, Cambridge.
1884. *Burland, Lieut.-Col. Jeffrey H. 824 Sherbrook-street, Montreal, Canada.
1899. ‡Burls, Herbert T. Care of Messrs. H. S. King & Co., Cornhill, E.C.
1905. §Burmeister, H. A. P. 78 Hout-street, Cape Town.
1904. ‡Burn, R. H. 21 Stanley-crescent, Notting Hill, W.
1888. ‡Burne, H. Holland. 28 Marlborough-buildings, Bath.
1883. *Burne, Major-General Sir Owen Tudor, G.C.I.E., K.C.S.I., F.R.G.S. 132 Sutherland-gardens, Maida Vale, W.
1876. ‡Burnet, John. 14 Victoria-crescent, Dowanhill, Glasgow.
1885. *Burnett, W. Kendall, M.A. Migvie House, North Silver-street, Aberdeen.
1877. ‡Burns, David. Vallum View, Burgh-road, Carlisle.
1884. ‡Burns, Professor James Austin. Southern Medical College, Atlanta, Georgia, U.S.A.
1899. ‡Burr, Malcolm. Dorman's Park, East Grinstead.
1905. §Burroughes, James S., F.R.G.S. Soho-square, W.
1894. ‡Burstall, H. F. W. 76 King's-road, Camden-road, N.W.
1891. ‡Burt, J. J. 103 Roath-road, Cardiff.
1888. ‡Burt, Sir John Mowlem. 3 St. John's-gardens, Kensington, W.
1888. ‡Burt, Lady. 3 St. John's-gardens, Kensington, W.
1894. ‡Burton, Charles V. 24 Wimpole-street, W.
1866. *BURTON, FREDERICK M., F.L.S., F.G.S. Highfield, Gainsborough.
1889. ‡Burton, Rev. R. Lingen. Little Aston, Sutton Coldfield.
1897. ‡Burton, S. H., M.B. 50 St. Giles's-street, Norwich.
1892. ‡Burton-Brown, Colonel Alexander, R.A., F.R.A.S., F.G.S. 11 Union-crescent, Margate.
1904. ‡Burtt, Arthur H., D.Sc. 4 South View, Holgate, York.
1897. ‡Burwash, Rev. N., LL.D., Principal of Victoria University, Toronto, Canada.
1887. *Bury, Henry. Mayfield House, Farnham, Surrey.

Year of Election.

1899. §Bush, Anthony. 43 Portland-road, Nottingham.
1895. ‡Bushe, Colonel C. K., F.G.S. 19 Cromwell-road, S.W.
1884. *Butcher, William Deane, M.R.C.S.Eng. Holyrood, 5 Cleveland-road, Ealing, W.
1884. ‡Butler, Matthew I. Napanee, Ontario, Canada.
1884. *Butterworth, W. Park-avenue, Temperley, near Manchester.
1872. ‡Buxton, Charles Louis. Cromer, Norfolk.
1905. §Buxton, Miss F. M. 42 Grosvenor-gardens, S.W.
1905. §Buxton, F. W. 42 Grosvenor-gardens, S.W.
1887. *Buxton, J. H. Clumber Cottage, Montague-road, Felixstowe.
1868. ‡Buxton, S. Gurney. Catton Hall, Norwich.
1881. ‡Buxton, Sydney C., M.P. 15 Eaton-place, S.W.
1872. ‡Buxton, Sir Thomas Fowell, Bart., G.C.M.G., F.R.G.S. Warlies, Waltham Abbey, Essex.
1899. §Byles, Arthur R. 'Bradford Observer,' Bradford, Yorkshire.
1852. ‡Byrne, Very Rev. James. Ergenagh Rectory, Omagh.
1883. ‡Byrom, John R. The Rowans, Fairfield, near Manchester.

1892. ‡Cadell, Henry M., B.Sc., F.R.S.E. Grange, Bo'ness, N.B.
1894. ‡Caillard, Miss E. M. Wingfield House, near Trowbridge, Wilts.
1863. ‡Caird, Edward. Finnart, Dumbartonshire.
1861. *Caird, James Key. 8 Roseangle, Dundee.
1905. §Calderwood, J. M. P.O. Box 2295, Johannesburg.
1901. ‡Caldwell, Hugh. Blackwood, Newport, Monmouthshire.
1868. ‡Caley, A. J. Norwich.
1887. ‡Callaway, Charles, M.A., D.Sc., F.G.S. 16 Montpellier-villas, Cheltenham.
1897. §Callendar, Hugh L., M.A., LL.D., F.R.S. (Council, 1900-), Professor of Physics in the Royal College of Science, S.W.
1892. ‡Calvert, A. F., F.R.G.S. Royston, Eton-avenue, N.W.
1901. ‡Calvert, H. T. Roscoe-terrace, Armley, Leeds.
1857. ‡Cameron, Sir Charles A., C.B., M.D. 15 Pembroke-road, Dublin.
1896. §Cameron, Irving H. 307 Sherbourne-street, Toronto, Canada.
1884. ‡Cameron, James C., M.D. 41 Belmont-park, Montreal, Canada.
1870. ‡Cameron, John, M.D. 17 Rodney-street, Liverpool.
1901. §Campbell, Archibald. Park Lodge, Albert-drive, Pollokshields, Glasgow.
1884. ‡Campbell, Archibald H. Toronto, Canada.
1876. ‡Campbell, Right Hon. James A., LL.D., M.P. Stracathro House, Brechin.
1897. ‡Campbell, Colonel J. C. L. Achalader, Blairgowrie, N.B.
1901. ‡Campbell, M. Pearce. 9 Lynedoch-crescent, Glasgow.
1902. ‡Campbell, Robert. 21 Great Victoria-street, Belfast.
1897. ‡Campion, B. W. Queen's College, Cambridge.
1882. ‡Candy, F. H. 71 High-street, Southampton.
1890. ‡Cannan, Edwin, M.A., LL.D., F.S.S. (Pres. F, 1902.) 46 Wellington-square, Oxford.
1905. §Cannan, Gilbert. King's College, Cambridge.
1897. §Cannon, Herbert. Woodbank, Erith, Kent.
1904. ‡Capell, Rev. G. M. Passenham Rectory, Stony Stratford.
1905. *Caporn, Dr. W. W. Roeland-street Baths, Cape Town.
1888. ‡Cappel, Sir Albert J. L., K.C.I.E. 27 Kensington Court-gardens, W.
1894. §Capper, D. S., M.A., Professor of Mechanical Engineering in King's College, W.C.
1887. ‡Capstick, John Walton. Trinity College, Cambridge.
1896. *Carden, H. Vandeleur. Fassaroe, Walmer.

Year of
Election.

1877. ‡Carkeet, John. 3 St. Andrew's-place, Plymouth.
1898. ‡Carlile, George M. 7 Upper Belgrave-road, Bristol.
1901. ‡Carlile, W. Warrand. Harlie, Largs, Ayrshire.
1867. ‡Carmichael, David (Engineer). Dundee.
1876. ‡Carmichael, Niel, M.D. 177 Nitherdale-road, Pollokshields, Glasgow.
1897. ‡Carmichael, Norman R. Queen's University, Kingston, Ontario, Canada.
1884. ‡Carnegie, John. Peterborough, Ontario, Canada.
1902. ‡Carpenter, G. H., B.Sc. Science and Art Museum, Dublin.
1884. ‡Carpenter, Louis G. Agricultural College, Fort Collins, Colorado, U.S.A.
1897. ‡Carpenter, R. C. Cornell University, Ithaca, New York, U.S.A.
1905. §Carpmael, Edward, F.R.A.S., M.Inst.C.E. 24 Southampton buildings, Chancery-lane, W.C.
1889. ‡Carr, Cuthbert Ellison. Hedgeley, Alnwick.
1893. ‡Carr, J. Wesley, M.A., F.L.S., F.G.S., Professor of Biology in University College, Nottingham.
1889. ‡Carr-Ellison, John Ralph. Hedgeley, Alnwick.
1905. §Carrick, Dr. P.O. Box 646, Johannesburg.
1867. ‡Carruthers, William, F.R.S., F.L.S., F.G.S. (Pres. D, 1886.) 14 Vermont-road, Norwood, S.E.
1886. ‡Carslake, J. Barham (Local Sec. 1886). 30 Westfield-road, Birmingham.
1899. ‡Carslaw, H. S., D.Sc., Professor of Mathematics in the University of Sydney, N.S.W.
1883. ‡Carson, John. 41 Royal-avenue, Belfast.
1903. *Cart, Rev. Henry. 49 Albert-court, Kensington Gore, S.W.
1868. *Carteighe, Michael, F.C.S., F.I.C. 180 New Bond-street, W.
1900. *Carter, Rev. W. Lower, M.A., F.G.S. Hopton, Mirfield, Yorkshire.
1870. ‡Carter, Dr. William. 78 Rodney-street, Liverpool.
1896. ‡Cartwright, Miss Edith G. 21 York Street-chambers, Bryanston-square, W.
1878. *Cartwright, Ernest H., M.A., M.D. Myskyns, Ticehurst, Sussex.
1870. §Cartwright, Joshua, M.Inst.C.E., F.S.I. Peel-chambers, Market-place, Bury, Lancashire.
1862. ‡Carulla, F. J. R. 84 Rosehill-street, Derby.
1894. ‡Carus, Paul. La Salle, Illinois, U.S.A.
1884. *Carver, Rev. Canon Alfred J., D.D., F.R.G.S. Lynnhurst, Streatham Common, S.W.
1884. ‡Carver, Mrs. Lynnhurst, Streatham Common, S.W.
1901. ‡Carver, Thomas A. B., B.Sc., Assoc. M.Inst.C.E. 118 Napiershall-street, Glasgow.
1887. ‡Casartelli, Rev. L. C., M.A., Ph.D. St. Bede's College, Manchester.
1899. *Case, J. Monckton. Town Office, Uitenhage, Cape Colony.
1897. *Case, Willard E. Auburn, New York, U.S.A.
1896. *Casey, James. 10 Philpot-lane, E.C.
1871. ‡Cash, Joseph. Bird-grove, Coventry.
1873. *Cash, William, F.G.S. 35 Commercial-street, Halifax.
1904. ‡Caspair, W. A. National Physical Laboratory, Bushy House, Teddington, Middlesex.
1900. *Cassie, W., M.A., Professor of Physics in the Royal Holloway College. Brantwood, Englefield Green.
1897. ‡Caston, Harry Edmonds Featherston. 340 Brunswick-avenue, Toronto, Canada.
1874. ‡Caton, Richard, M.D. Lea Hall, Gateacre, Liverpool.

Year of Election.

1859. ‡Catto, Robert. 44 King-street, Aberdeen.
1886. *Cave-Moyle, Mrs. Isabella. St. Paul's Vicarage, Cheltenham.
Cayley, Digby. Brompton, near Scarborough.
1905. *Challenor, Bromley. The Firs, Abingdon.
1905. §Challenor, Miss E. M. The Firs, Abingdon.
1859. ‡Chalmers, John Inglis. Aldbar, Aberdeen.
1905. §Chamberlain, Miss H. H. Ingleneuk, Upper St. John's-road, Sea Point, Cape Colony.
1901. §Chamen, W. A. 75 Waterloo-street, Glasgow.
1905. §Champion, G. A. Haraldene, Chelmsford-road, Durban, Natal.
1881. *Champney, John E. 27 Hans-place, S.W.
1865. ‡Chance, A. M. Edgbaston, Birmingham.
1865. ‡Chance, Robert Lucas. Chad Hill, Edgbaston, Birmingham.
1888. ‡Chandler, S. Whitty, B.A. Sherborne, Dorset.
1902. §Chapman, D. L. 10 Parsonage-road, Withington, Manchester.
1861. *Chapman, Edward, M.A., M.P., F.L.S., F.C.S. Hill End, Mottram, Manchester.
1897. ‡Chapman, Edward Henry. 17 St. Hilda's-terrace, Whitby.
1889. ‡Chapman, L. H. 147 Park-road, Newcastle-upon-Tyne.
1899. §Chapman, Professor Sydney John, M.A. Victoria University, Manchester.
1877. ‡Chapman, T. Algernon, M.D. 17 Wesley-avenue, Liscard, Cheshire.
1874. ‡Charles, J. J., M.D., Professor of Anatomy and Physiology in Queen's College, Cork. Newmarket, Co. Cork.
1874. ‡Charley, William. Seymour Hill, Dunmurry, Ireland.
1905. §Chassigneux, E. 12 Tavistock-road, Westbourne Park, W.
1903. ‡Chaster, G. W. 42 Talbot-road, Southport.
1886. ‡*Chate, Robert W. Southfield, Edgbaston, Birmingham.*
1904. *Chattaway, F. D. Longfield, Kenton-road, Harrow.
1884. *CHATTERTON, GEORGE, M.A., M.Inst.C.E. 6 The Sanctuary, Westminster, S.W.
1886. *CHATTOCK, A. P., M.A., Professor of Experimental Physics in University College, Bristol.
1867. *Chatwood, Samuel, F.R.G.S. High Lawn, Broad Oak Park, Worsley, Manchester.
1904. *Chaundy, Theodore William. 49 Broad-street, Oxford.
1884. ‡CHAUVEAU, The Hon. Dr. Montreal, Canada.
1883. ‡Chawner, W., M.A. Emmanuel College, Cambridge.
1864. ‡CHEADLE, W. B., M.A., M.D., F.R.G.S. 19 Portman-street, Portman-square, W.
1900. §Cheesman, W. Norwood, F.L.S. The Crescent, Selby.
1896. ‡Chenie, John. Charlotte-street, Edinburgh.
1874. *Chermside, Major-General Sir H. C., R.E., G.C.M.G., C.B. Care of Messrs. Cox & Co., Craig's-court, Charing Cross, S.W.
1896. ‡Cherry, R. B. 92 Stephen's-green, Dublin.
1879. *Chesterman, W. Belmayne, Sheffield.
1883. ‡Chinery, Edward F. Monmouth House, Lymington.
1884. ‡Chipman, W. W. L. 957 Dorchester-street, Montreal, Canada.
1889. ‡Chirney, J. W. Morpeth.
1894. ‡CHISHOLM, G. G., M.A., B.Sc., F.R.G.S. 59 Drakefield-road, Upper Tooting, S.W.
1900. ‡CHISHOLM, Sir SAMUEL. Glasgow.
1899. §Chitty, Edward. Sonnenberg, Castle-avenue, Dover.
1899. §Chitty, Mrs. Edward. Sonnenberg, Castle-avenue, Dover.
1899. §Chitty, G. W. Brockhill Park, Hythe, Kent.
1904. §Chivers, John, J.P. Histon, Cambridgeshire.
1882. ‡Chorley, George. Midhurst, Sussex.

Year of Election.

1893. *CHREE, CHARLES, D.Sc., F.R.S. Kew Observatory, Richmond, Surrey.
1900. *Christie, R. J. Duke Street, Toronto, Canada.
1875. *Christopher, George, F.C.S. May Villa, Lucien-road, Tooting Common, S.W.
1876. *CHRYSTAL, GEORGE, M.A., LL.D., F.R.S.E. (Pres. A, 1885), Professor of Mathematics in the University of Edinburgh. 5 Belgrave-crescent, Edinburgh.
1905. §Chudleigh, C. P.O. Box 743, Johannesburg.
1870. §CHURCH, A. H., M.A., F.R.S., F.S.A., Professor of Chemistry in the Royal Academy of Arts. Shelsley, Ennerdale-road, Kew.
1898. §CHURCH, Colonel G. EARL, F.R.G.S. (Pres. E, 1898.) 216 Cromwell-road, S.W.
1860. ‡CHURCH, Sir WILLIAM SELBY, Bart., M.D., D.Sc. St. Bartholomew's Hospital, E.C.
1896. ‡Clague, Daniel, F.G.S. 68 Brainerd-street, Tue Brook, Liverpool.
1903. §Clapham, J. H., M.A., Professor of Economics in the University of Leeds.
1901. §Clark, Archibald B., M.A. 16 Comely Bank-street, Edinburgh.
1905. *Clark, Cumberland, F.R.G.S. 29 Chepstow-villas, Bayswater, W.
1876. ‡Clark, David R., M.A. 8 Park-drive West, Glasgow.
1890. ‡*Clark, E. K.* 13 *Wellclose-place, Leeds.*
1877. *Clark, F. J., J.P., F.L.S. Netherleigh, Street, Somerset.
1902. ‡Clark, G. M. Cape Town.
1881. *Clark, J. Edmund, B.A., B.Sc. Asgarth, Riddlesdown-road, Purley, Surrey.
1892. ‡Clark, James. Chapel House, Paisley.
1901. ‡Clark, James M., M.A., B.Sc. 8 Park-drive West, Glasgow.
1876. ‡Clark, Dr. John. 138 Bath-street, Glasgow.
1901. *Clark, Robert M., B.Sc., F.L.S. 27 Albyn-place, Aberdeen.
1855. ‡Clark, Rev. William, M.A. Beechcroft, Jordan-hill, Glasgow.
1887. ‡Clarke, C. Goddard, J.P. South Lodge, Champion-hill, S.E.
1875. ‡Clarke, Charles S. 4 Worcester-terrace, Clifton, Bristol.
1886. ‡Clarke, David. Langley-road, Small Heath, Birmingham.
1875. ‡CLARKE, JOHN HENRY. (Local Sec. 1875.) 4 Worcester-terrace, Clifton, Bristol.
1902. §Clarke, Miss Lilian J., B.Sc., F.L.S. 43 Glasslyn-road, Crouch End, N.
1905. §Clarke, Rev. W. E. C., M.A. P.O. Box 1144, Pretoria.
1896. ‡Clarke, W. W. Albert Dock Office, Liverpool.
1884. ‡Claxton, T. James. 461 St. Urbain-street, Montreal, Canada.
1889. *CLAYDEN, A. W., M.A., F.G.S. St. John's, Polsloe-road, Exeter.
1890. *Clayton, William Wikely. Gipton Lodge, Leeds.
1861. ‡CLELAND, JOHN, M.D., D.Sc., F.R.S., Professor of Anatomy in the University of Glasgow. 2 The University, Glasgow.
1905. §Cleland, J. R. 2 The University, Glasgow.
1905. §Cleland, Mrs. 2 The University, Glasgow.
1902. §Clements, Olaf P. Tana, St. Bernard's-road, Olton, Warwick.
1904. §Clerk, Dugald, M.Inst.C.E. 18 Southampton-buildings, W.C.
1861. *CLIFTON, R. BELLAMY, M.A., F.R.S., F.R.A.S., Professor of Experimental Philosophy in the University of Oxford. 3 Bardwell-road, Banbury-road, Oxford.
1898. ‡Clissold, H. 30 College-road, Clifton, Bristol.
1893. ‡Clofford, William. 36 Mansfield-road, Nottingham.
1873. ‡Clough, John. Bracken Bank, Keighley, Yorkshire.
1892. ‡Clouston, T. S., M.D. Tipperlinn House, Edinburgh.
1883. *CLOWES, FRANK, D.Sc., F.C.S. (Local Sec. 1893.) The Grange, College-road, Dulwich, S.E.

Year of Election.

1885. ‡Clyne, James. Rubislaw Den South, Aberdeen.
1891. *Coates, Henry. Pitcullen House, Perth.
1897. ‡Coates, J., M.Inst.C.E. 99 Queen-street, Melbourne, Australia.
1903. *Coates, W. M. Queen's College, Cambridge.
1901. ‡Coats, Allan. Hayfield, Paisley.
1884. §Cobb, John. Fitzherries, Abingdon.
1895. *COBBOLD, FELIX T., M.A. The Lodge, Felixstowe, Suffolk.
1889. ‡Cochrane, Cecil A. Oakfield House, Gosforth, Newcastle-upon-Tyne.
1864. *Cochrane, James Henry. Burston House, Pittville, Cheltenham.
1889. ‡Cochrane, William. Oakfield House, Gosforth, Newcastle-upon-Tyne.
1901. ‡Cockburn, Sir John, K.C.M.G., M.D. 10 Gatestone-road, Upper Norwood, S.E.
1883. ‡Cockshott, J. J. 24 Queen's-road, Southport.
1861. *Coe, Rev. Charles C., F.R.G S. Whinsbridge, Grosvenor-road, Bournemouth.
1898. ‡Coffey, George. 5 Harcourt-terrace, Dublin.
1881. *COFFIN, WALTER HARRIS, F.C.S. 26 Belgrave-road, Eccleston-square, S.W.
1896. *Coghill, Percy de G. 4 Sunnyside, Prince's Park, Liverpool.
1884. *Cohen, Sir Benjamin L., Bart., M.P. 30 Hyde Park-gardens, W.
1887. ‡Cohen, Julius B. Yorkshire College, Leeds.
1901. §Cohen, N. L. 11 Hyde Park-terrace, W.
1901. *Cohen, R. Waley, B.A. 11 Sussex-square, W.
1895. *Colby, James George Ernest, M.A., F.R.C.S. Malton, Yorkshire.
1895. *Colby, William Henry. Carregwen, Aberystwyth.
1893. §Cole, Professor Grenville A. J., F.G.S. Royal College of Science, Dublin.
1903. ‡Cole, Otto B. 551 Boylston-street, Boston, U.S.A.
1879. ‡Cole, Skelton. 387 Glossop-road, Sheffield.
1897. §COLEMAN, Dr. A. P. 476 Huron-street, Toronto, Canada.
1893. ‡Coleman, J. B., F.C.S., A.R.C.S. University College, Nottingham.
1899. §Coleman, William. The Shrubbery, Buckland, Dover.
1878. ‡Coles, John, F.R.G.S. Liphook, Hants.
1854. *Colfox, William, B.A. Westmead, Bridport, Dorsetshire.
1899. ‡Collard, George. The Gables, Canterbury.
1892. ‡Collet, Miss Clara E. 7 Coleridge-road, N.
1892. ‡Collie, Alexander. Harlaw House, Inverurie.
1887. ‡COLLIE, J. NORMAN, Ph.D., F.R.S., Professor of Organic Chemistry in the University of London. 16 Campden-grove, W.
1869. ‡Collier, W. F. Woodtown, Horrabridge, South Devon.
1893. ‡Collinge, Walter E. The University, Birmingham.
1861. *Collingwood, J. Frederick, F.G.S. 5 Irene-road, Parson's Green, S.W.
1876. ‡COLLINS, J. H., F.G.S. 162 Barry-road, S.E.
1865. *Collins, James Tertius. Churchfield, Edgbaston, Birmingham.
1905. §Collins, Rev. Spencer. The Rectory, Victoria West, Cape Colony.
1902. ‡Collins, T. R. Belfast Royal Academy, Belfast.
1882. ‡Colmer, Joseph G., C.M.G. Office of the High Commissioner for Canada, 17 Victoria-street, S.W.
1884. ‡Colomb, Right Hon. Sir J. C. R., K.C.M.G., M.P., F.R.G.S. Dromquinna, Kenmare, Kerry, Ireland; and Junior United Service Club, S.W.
1897. ‡Colquhoun, A. H. U., B.A. 39 Borden-street, Toronto, Canada.
1905. *Combs, Rev. Cyril W., M.A. Elverton, Castle-road, Newport, Isle of Wight.
1888. †Commans, R. D. Macaulay-buildings, Bath.
1900. ‡Common, T. A., B.A. 63 Eaton-rise, Ealing, W.

Year of Election.

1870. *COMPTON, The Right Rev. Lord ALWYNE, D.D. 37 Dover-street, Piccadilly.
1892. ‡Comyns, Frank, M.A., F.C.S. The Grammar School, Durham.
1884. ‡Conklin, Dr. William A. Central Park, New York, U.S.A.
1890. ‡Connon, J. W. Park-row, Leeds.
1871. *Connor, Charles C. 4 Queen's Elms, Belfast.
1902. ‡Conway, A. W. 100 Leinster-road, Rathmines, Dublin.
1903. ‡Conway, R. Seymour, Litt.D., Professor of Latin in Owens College, Manchester.
1893. ‡CONWAY, Professor Sir W. M., M.A., F.R.G.S. The Red House, Hornton-street, W.
1899. ‡COODE, J. CHARLES, M.Inst.C.E. Westminster-chambers, 9 Victoria-street, S.W.
1898. §Cook, Ernest H. 27 Berkeley-square, Clifton, Bristol.
1900. ‡Cook, Walter. 98 St. Mary's-street, Cardiff.
1876. *COOKE, CONRAD W. 28 Victoria-street, S.W.
1881. ‡Cooke, F. Bishopshill, York.
1868. ‡Cooke, Rev. George H. Wanstead Vicarage, near Norwich.
1868. ‡COOKE, M. C., M.A. 53 Castle-road, Kentish Town, N.W.
1884. ‡Cooke, R. P. Brockville, Ontario, Canada.
1881. ‡Cooke, Thomas. Bishopshill, York.
1896. ‡Cookson, E. H. Kiln Hey, West Derby.
1888. ‡Cooley, George Parkin. Constitutional Club, Nottingham.
1899. *Coomáraswámy, A. K., B.Sc., F.L.S., F.G.S., Director of the Mineral Survey of Ceylon. Kandy, Ceylon.
1902. *Coomáraswámy, Mrs. A. K. Kandy, Ceylon.
1903. §Cooper, Miss A. J. 22 St. John-street, Oxford.
1901. *Cooper, C. Forster, B.A. Trinity College, Cambridge.
1895. ‡*Cooper, Charles Friend, M.I.E.E.* 68 *Victoria-street, Westminster, S.W.*
1868. ‡Cooper, W. J. New Malden, Surrey.
1889. ‡Coote, Arthur. The Minories, Jesmond, Newcastle-upon-Tyne.
1878. ‡Cope, Rev. S. W. Bramley, Leeds.
1904. *COPEMAN, S. MONCKTON, M.D., F.R.S. Local Government Board, Whitehall, S.W.
1904. *Copland, Miss Louisa. 14 Brunswick-gardens, Kensington, W.
1881. ‡Copperthwaite, H. Holgate Villa, Holgate-lane, York.
1905. §Corben, J. H. Education Department, Klerksdorp, Transvaal.
1901. §Corbett, A. Cameron, M.P. Thornliebank House, Glasgow.
1891. ‡Corbett, E. W. M. Y Fron, Pwllypant, Cardiff.
1887. *Corcoran, Bryan. Fairlight, 22 Oliver-grove, South Norwood, S.E.
1894. §Corcoran, Miss Jessie R. The Chestnuts, Mulgrave-road, Sutton, Surrey.
1883. *Core, Professor Thomas H., M.A. Groombridge House, Withington, Manchester.
1901. *Cormack, Professor J. D., B.Sc. University College, Gower-street, W.C.
1893. **Corner, Samuel, B.A., B.Sc.* 95 *Forest-road West, Nottingham.*
1889. ‡CORNISH, VAUGHAN, D.Sc., F.R.G.S. 72 Prince's-square, W.
1905. §Cornish-Bowden, A. H. Surveyor-General's Office, Cape Town.
1884. *Cornwallis, F. S. W., M.P., F.L.S. Linton Park, Maidstone.
1885. ‡Corry, John. Rosenheim, Park Hill-road, Croydon.
1888. ‡Corser, Rev. Richard K. 57 Park Hill-road, Croydon.
1900. §Cortie, Rev. A. L., S.J., F.R.A.S. Stonyhurst College, Blackburn.
1905. §Cory, Professor G. E., M.A. Rhodes University College, Grahams Town, Cape Colony.
1891. ‡Cory, John, J.P. Vaindre Hall, near Cardiff.

Year of Election.

1891. ‡Cory, Alderman Richard, J.P. Oscar House, Newport-road, Cardiff.
1874. *Cotterill, J. H., M.A., F.R.S. Braeside, Speldhurst, Kent.
1905. §Cottrill, G. St. John. P.O. Box 4829, Johannesburg.
1904. ‡Coulter, G. G. 28 Pall Mall, S.W.
1876. ‡Couper, James. City Glass Works, Glasgow.
1876. ‡Couper, James, jun. City Glass Works, Glasgow.
1896. ‡Courtney, Right Hon. Leonard (Pres. F, 1896). 15 Cheyne-walk, Chelsea, S.W.
1905. §Cousens, R. L. P.O. Box 4261, Johannesburg.
1890. ‡Cousins, John James. Allerton Park, Chapel Allerton, Leeds.
1896. ‡Coventry, J. 19 Sweeting-street, Liverpool.
Cowan, John. Valleyfield, Pennycuick, Edinburgh.
1863. ‡Cowan, John A. Blaydon Burn, Durham.
1872. *Cowan, Thomas William, F.L.S., F.G.S. 8 Henrietta-street, Covent Garden, W.C.
1903. ‡Coward, H. Knowle Board School, Bristol.
1900. ‡Cowburn, Henry. Dingle Head, Westleigh, Leigh, Lancashire.
1905. §Cowell, John Ray. P.O. Box 2141, Johannesburg.
1895. *Cowell, Philip H., M.A. Royal Observatory, Greenwich, and 74 Vanbrugh-park, Blackheath, S.E.
1899. ‡Cowper-Coles, Sherard. 82 Victoria-street, S.W.
1867. *Cox, Edward. Cardean, Meigle, N.B.
1892. ‡Cox, Robert. 34 Drumsheugh-gardens, Edinburgh.
1882. ‡Cox, Thomas A., District Engineer of the S., P., and D. Railway, Lahore, Punjab. Care of Messrs. Grindlay & Co., Parliament-street, S.W.
1888. ‡Cox, Thomas W. B. The Chestnuts, Lansdowne, Bath.
1867. ‡Cox, William. Foggley, Lochee, by Dundee.
1905. §Cox, W. H. Royal Observatory, Cape Town.
1890. ‡Cradock, George. Wakefield.
1902. ‡Craig, H. C. Strandtown, Belfast.
1884. §Craigie, Major P. G., C.B., F.S.S. (Pres. F, 1900.) Board of Agriculture and Fisheries, 3 St. James's-square, S.W.
1876. ‡Cramb, John. Larch Villa, Helensburgh, N.B.
1905. *Cranswick, Wm. Franceys. 34 Boshof-road, Kimberley.
1884. ‡Crathern, James. Sherbrooke-street, Montreal, Canada.
1887. *Craven, Thomas, J.P. Woodheyes Park, Ashton-upon-Mersey.
1905. §Crawford, Mrs. A. M. Marchmont, Rosebank, near Cape Town.
1905. §Crawford, Professor Lawrence, M.A., D.Sc., F.R.S.E. South African College, Cape Town.
1871. *Crawford, William Caldwell, M.A. 1 Lockharton-gardens, Colinton-road, Edinburgh.
1905. §Crawford, W. C., jun. 1 Lockharton Gardens, Colington-road, Edinburgh.
1871. *Crawford and Balcarres, The Right Hon. the Earl of, K.T., LL.D., F.R.S., F.R.A.S. 2 Cavendish-square, W.; and Haigh Hall, Wigan.
1846. *Crawshaw, The Right Hon. Lord. Whatton, Loughborough.
1890. §Crawshaw, Charles B. Rufford Lodge, Dewsbury.
1883. *Crawshaw, Edward, F.R.G.S. 25 Tollington-park, N.
1870. *Crawshay, Mrs. Robert. Caversham Park, Reading.
1885. §Creak, Captain E. W., C.B., R.N., F.R.S. (Pres. E., 1903; Council 1896–1903.) 9 Hervey-road, Blackheath, S.E.
1901. ‡Cree, T. S. 15 Montgomerie-quadrant, Glasgow.
1896. ‡Cregeen, A. C. 21 Prince's-avenue, Liverpool.
1879. ‡Creswick, Nathaniel. Chantry Grange, near Sheffield.
1876. *Crewdson, Rev. Canon George. St. Mary's Vicarage, Windermere.

Year of Election.

1887. *Crewdson, Theodore. Norcliffe Hall, Handforth, Manchester.
1896. ‡Crichton, Hugh. 6 Rockfield-road, Anfield, Liverpool.
1904. ‡Crilly, David. 7 Well-street, Paisley.
1880. *Crisp, Frank, B.A., LL.B., F.L.S., F.G.S. 5 Lansdowne-road, Notting Hill, W.
1905. §Croft, Miss Mary. 17 Pelham-crescent, S.W.
1890. *Croft, W. B., M.A. Winchester College, Hampshire.
1878. ‡Croke, John O'Byrne, M.A. Clouneagh, Ballingarry-Lacy, Co. Limerick.
1857. ‡Crolly, Rev. George. Maynooth College, Ireland.
1885. ‡CROMBIE, J. W., M.A., M.P. (Local Sec. 1885). Balgownie Lodge, Aberdeen.
1885. ‡Crombie, Theodore. 18 Albyn-place, Aberdeen.
1903. *Crompton, Holland. Binfield, Northwood, Middlesex.
1901. ‡CROMPTON, Colonel R. E., C.B., M.Inst.C.E. (Pres. G, 1901.) Kensington Court, W.
1887. ‡CROOK, HENRY T., M.Inst.C.E. 9 Albert-square, Manchester.
1898. §Crooke, William. Langton House, Charlton Kings, Cheltenham.
1865. §CROOKES, Sir WILLIAM, D.Sc., F.R.S., V.P.C.S. (PRESIDENT, 1898; Pres. B, 1886; Council 1885-91.) 7 Kensington Park-gardens, W.
1879. ‡Crookes, Lady. 7 Kensington Park-gardens, W.
1897. *CROOKSHANK, E. M., M.B. Ashdown Forest, Forest Row, Sussex.
1870. ‡Crosfield, C. J. Gledhill, Sefton Park, Liverpool.
1905. §Crosfield, Hugh T. King's College, Cambridge.
1894. *Crosfield, Miss Margaret C. Undercroft, Reigate.
1870. *CROSFIELD, WILLIAM. 3 Fulwood-park, Liverpool.
1904. §Cross, Professor Charles R. Massachusetts Institute of Technology, Boston, U.S.A.
1890. ‡Cross, E. Richard, LL.B. Harwood House, New Parks-crescent, Scarborough.
1905. §Cross, Robert. 13 Moray-place, Edinburgh.
1853. ‡Crosskill, William. Beverley, Yorkshire.
1904. *CROSSLEY, A. W., D.Sc., Ph.D., Professor of Chemistry to the Pharmaceutical Society of Great Britain. 10 Crediton-road, West Hampstead, N.W.
1887. *Crossley, William J. Glenfield, Bowdon, Cheshire.
1894. *Crosweller, William Thomas, F.Z.S., F.I.Inst. Kent Lodge, Sidcup, Kent.
1897. *Crosweller, Mrs. W. T. Kent Lodge, Sidcup, Kent.
1883. ‡Crowder, Robert. Stanwix, Carlisle.
1882. §Crowley, Frederick. Ashdell, Alton, Hampshire.
1890. *Crowley, Ralph Henry, M.D. 116 Manningham-lane, Bradford.
1863. ‡Cruddas, George. Elswick Engine Works, Newcastle-upon-Tyne.
1885. ‡Cruickshank, Alexander, LL.D. 20 Rose-street, Aberdeen.
1888. ‡Crummack, William J. London and Brazilian Bank, Rio de Janeiro, Brazil.
1898. ‡CRUNDALL, Sir WILLIAM H. Dover.
1888. ‡Culley, Robert. Bank of Ireland, Dublin.
1883. *CULVERWELL, EDWARD P., M.A., Professor of Education in Trinity College, Dublin.
1883. ‡Culverwell, T. J. H. Litfield House, Clifton, Bristol.
1897. ‡Cumberland, Barlow. Toronto, Canada.
1898. §Cundall, J. Tudor. 1 Dean Park-crescent, Edinburgh.
1861. *Cunliffe, Edward Thomas. The Parsonage, Handforth, Manchester.

Year of Election.

1861. *Cunliffe, Peter Gibson. Dunedin, Handforth, Manchester.
1905. §Cunningham, Miss A. 2 St. Paul's-road, Cambridge.
1882. *CUNNINGHAM, Lieut.-Colonel ALLAN, R.E., A I.C.E. 20 Essex-villas, Kensington, W.
1905. §Cunningham, Andrew. Earlsferry, Campground-road, Mowbray, South Africa.
1877. *CUNNINGHAM, D. J., M.D., D.C.L., F.R.S., F.R.S.E. (Pres. H, 1901; Council, 1902–), Professor of Anatomy in the University of Edinburgh.
1891. ‡Cunningham, J. H. 2 Ravelston-place, Edinburgh.
1885. ‡CUNNINGHAM, J. T., B.A. Biological Laboratory, Plymouth.
1869. ‡CUNNINGHAM, ROBERT O., M.D., F.L.S., F.G.S., Professor of Natural History in Queen's College, Belfast.
1883. *CUNNINGHAM, Rev. W., D.D., D.Sc. (Pres. F, 1891, 1905). Trinity College, Cambridge.
1892. §Cunningham-Craig, E. H., B.A., F.G.S. 14A Dublin-street, Edinburgh.
1900. *Cunnington, W. Alfred. 13 The Chase, Clapham Common, S.W.
1892. *Currie, James, M.A., F.R.S.E. Larkfield, Wardie-road, Edinburgh.
1905. §Currie, Dr. O. J. 24 Longmarket-street, Pietermaritzburg, Natal.
1905. §Currie, W. P. P.O. Box 2010, Johannesburg.
1884. ‡Currier, John McNab. Newport, Vermont, U.S.A.
1902. ‡Curry, Professor M., M.Inst.C.E. 5 King's-gardens, Hove.
1898. ‡Curtis, John. 1 Christchurch-road, Clifton, Bristol.
1878. ‡Curtis, William. Caramore, Sutton, Co. Dublin.
1883. ‡Cushing, Mrs. M. Allee-strasse 7EI, Hanover, Germany.
1881. §Cushing, Thomas, F.R.A.S. Allee-strasse 7EI, Hanover, Germany.
1905. §Cuthbert, W. M. The Red House, Kenilworth, Cape Colony.
1905. §Cuthbert, Mrs. W. M. The Red House, Kenilworth, Cape Colony.

1854. ‡Daglish, Robert. Orrell Cottage, near Wigan.
1883. ‡Dähne, F. W., Consul of the German Empire. 18 Somerset-place, Swansea.
1898. §Dalby, W. E., D.Sc., M.Inst.C.E., Professor of Civil and Mechanical Engineering in the City and Guilds of London Institute, Exhibition-road, S.W. 45 Clifton-road, Crouch End, N.
1889. *Dale, Miss Elizabeth. 45 Oxford-road, Cambridge.
1863. ‡Dale, J. B. South Shields.
1867. ‡Dalgleish, W. Dundee.
1870. ‡DALLINGER, Rev. W. H., D.D., LL.D., F.R.S., F.L.S. Ingleside, Newstead-road, Lee, S.E.
1904. *DALTON, J. H. C., M.D. The Plot, Adams-road, Cambridge.
1862. ‡DANBY, T. W., M.A., F.G.S. The Crouch, Seaford, Sussex.
1905. §Daniel, Miss A. M. 3 St. John's-terrace, Weston-super-Mare.
1901. ‡Daniell, G. F., B.Sc. 44 Cavendish-road, Brondesbury, N.W.
1876. *Dansken, John, F.R.A.S. 2 Hillside-gardens, Partickhill, Glasgow.
1896. §Danson, F. C. Liverpool and London Chambers, Dale-street, Liverpool.
1849. *Danson, Joseph, F.C.S. Montreal, Canada.
1894. ‡Darbishire, B. V., M.A., F.R.G.S. 1 Savile-row, W.
1897. ‡Darbishire, C. W. Elm Lodge, Elm-row, Hampstead, N.W.
1897. §Darbishire, F. V., B.A., Ph.D. South-Eastern Agricultural College, Wye, Kent.
1903. §Darbishire, Dr. Otto V. The University, Manchester.
1861. *DARBISHIRE, ROBERT DUKINFIELD, B.A. (Local Sec. 1861.) Victoria Park, Manchester.

Year of Election.

1896. ‡Darbishire, W. A. Penybryn, Carnarvon, North Wales.
1904. *Darwin, Charles Galton. Newnham Grange, Cambridge.
1899. *Darwin, Erasmus. The Orchard, Huntingdon-road, Cambridge.
1882. ‡DARWIN, FRANCIS, M.A., M.B., F.R.S., F.L.S. (Pres. D, 1891; Pres. K, 1904; Council 1882–84, 1897–1901.) 30 Kensington-square, W.
1881. *DARWIN, Sir GEORGE HOWARD, K.C.B., M.A., LL.D., F.R.S., F.R.A.S. (PRESIDENT; Pres. A, 1886; Council 1886–92), Plumian Professor of Astronomy and Experimental Philosophy in the University of Cambridge. Newnham Grange, Cambridge.
1905. §Darwin, Lady. Newnham Grange, Cambridge.
1878. *DARWIN, HORACE, M.A., F.R.S. The Orchard, Huntingdon-road, Cambridge.
1894. *DARWIN, Major LEONARD, Hon. Sec. R.G.S. (Pres. E, 1896; Council 1899–1905.) 12 Egerton-place, South Kensington, S.W.
1882. ‡Darwin, W. E., M.A., F.G.S. 11 Egerton-place, S.W.
1880. *DAVEY, HENRY, M.Inst.C.E., F.G.S. Parliament-chambers, Great Smith-street, Westminster, S.W.
1898. ‡Davey, William John. 6 Water-street, Liverpool.
1884. ‡David, A. J., B.A., LL.B. 4 Harcourt-buildings, Temple, E.C.
1904. §Davidge, H. T., B.Sc., Professor of Electricity in the Ordnance College, Woolwich.
1870. ‡Davidson, Alexander, M.D. 2 Gambier-terrace, Liverpool.
1902. *Davidson, S. C. Seacourt, Bangor, Co. Down.
1870. ‡Davies, Edward, F.C.S. Royal Institution, Liverpool.
1887. *Davies, H. Rees. Treborth, Bangor, North Wales.
1904. §Davies, Henry N. St. Chad's, Weston-super-Mare.
1893. *Davies, Rev. T. Witton, B.A., Ph.D., Professor of Semitic Languages in University College, Bangor, North Wales.
1896. *Davies, Thomas Wilberforce, F.G.S. 41 Park-place, Cardiff.
1898. ‡Davies, Wm. Howell, J.P. Down House, Stoke Bishop, Bristol.
1870. *Davis, A. S. St. George's School, Roundhay, near Leeds.
1873. *Davis, Alfred. 37 Ladbroke-grove, W.
1905. §Davis, C. R. S. National Bank-buildings, Johannesburg.
1882. ‡Davis, Henry C. Berry Pomeroy, Springfield-road, Brighton.
1896. *Davis, John Henry Grant. Hillsborough, Wednesbury, Staffordshire.
1905. §Davis, Luther. 20 Frogmore-street, Abergavenny.
1885. *Davis, Rev. Rudolf. 23 Northfield, Bridgwater.
1886. ‡Davis, W. H. Hazeldean, Pershore-road, Birmingham.
1886. ‡DAVISON, CHARLES, D.Sc. 16 Manor-road, Birmingham.
1905. §Davy, Mrs. Alice Burtt. P.O. Box 434, Pretoria.
1857. ‡DAVY, E. W., M.D. Kimmage Lodge, Roundtown, Dublin.
1905. §Davy, Joseph Burtt, F.R.G.S., F.L.S. P.O. Box 434, Pretoria.
1869. ‡Daw, John. Mount Radford, Exeter.
1869. ‡Daw, R. R. M. Bedford-circus, Exeter.
1860. *Dawes, John T. The Lilacs, Prestatyn, North Wales.
1864. ‡DAWKINS, W. BOYD, D.Sc., F.R.S., F.S.A., F.G.S. (Pres. C, 1888; Council, 1882–88), Professor of Geology and Palæontology in the University of Manchester. Fallowfield House, Fallowfield, Manchester.
1886. ‡Dawson, Bernard. The Laurels, Malvern Link.
1891. ‡Dawson, Edward. 2 Windsor-place, Cardiff.
1885. *Dawson, Lieut.-Colonel H. P., R.A. Hartlington, Burnsall, Skipton-in-Craven.
1901. *Dawson, P. The Acre, Maryhill, Glasgow.
1905. §Dawson, Mrs. The Acre, Maryhill, Glasgow.

Year of Election.

1884. ‡DAWSON, SAMUEL. (Local Sec. 1884.) 258 University-street, Montreal, Canada.
1892. ‡Day, T. C., F.C.S. 36 Hillside-crescent, Edinburgh.
1870. *DEACON, G. F., LL. D., M.Inst.C.E. (Pres. G, 1897.) 19 Warwick-square, S.W.
1900. §Deacon, M. Whittington House, near Chesterfield.
1887. ‡Deakin, H. T. Egremont House, Belmont, near Bolton.
1861. ‡Dean, Henry. Colne, Lancashire.
1901. *Deasy, Capt. H. H. P. Cavalry Club, Piccadilly, W.
1884. *Debenham, Frank, F.S.S. 1 Fitzjohn's-avenue, N.W.
1866. ‡DEBUS, HEINRICH, Ph.D., F.R.S., F.C.S. (Pres. B, 1869; Council, 1870–75). 4 Schlangenweg, Cassel, Hessen.
1884. ‡Deck, Arthur, F.C.S. 9 King's-parade, Cambridge.
1893. ‡Deeley, R. M. 38 Charnwood-street, Derby.
1878. ‡Delany, Rev. William. University College, Dublin.
1896. §Dempster, John. Tynron, Noctorum, Birkenhead.
1902. ‡Dendy, Arthur, Professor of Zoology in King's College, London, W.C.
1897. ‡Denison, F. Napier. Meteorological Office, Victoria, B.C., Canada.
1896. ‡Denison, Miss Louisa E. 16 Chesham-place, S.W.
1889. §DENNY, ALFRED, F.L.S., Professor of Biology in the University of Sheffield.
1905. §Denny, G. A. P.O. Box 4181, Johannesburg.
1874. ‡DE RANCE, CHARLES E., F.G.S. 33 Carshalton-road, Blackpool.
1896. ‡DERBY, The Right Hon. the Earl of, K.G., G.C.B. Knowsley, Prescot, Lancashire.
1874. *Derham, Walter, M.A., LL.M., F.G.S. 76 Lancaster-gate, W.
1894. *Deverell, F. H. 7 Grote's-place, Blackheath, S.E.
1903. ‡Devereux, Rev. E. R. Price. Drachenfeld, Tenison-avenue, Cambridge.
1899. ‡DEVONSHIRE, The Duke of, K.G., D.C.L., F.R.S. Devonshire House, Piccadilly, W.
1899. ‡*Dewar, A. Redcote. Redcote, Leven, Fife.*
1868. *DEWAR, SIR JAMES, M.A., LL.D., D.Sc., F.R.S., F.R.S.E., V.P.C.S., Fullerian Professor of Chemistry in the Royal Institution, London, and Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge. (PRESIDENT, 1902; Pres. B, 1879; Council 1883–88.) 1 Scroope-terrace, Cambridge.
1881. ‡Dewar, Lady. 1 Scroope-terrace, Cambridge.
1883. ‡Dewar, James, M.D., F.R.C.S.E. Drylaw House, Davidson's Mains, Midlothian, N.B.
1905. §Dewar, W. R. Agricultural Department, Bloemfontein, South Africa.
1884. *Dewar, William, M.A. Horton House, Rugby.
1905. §Dewhirst, Miss May. Pembroke House, Oxford-road, Colchester.
1872. ‡Dewick, Rev. E. S., M.A., F.G.S. 26 Oxford-square, W.
1884. ‡De Wolf, O. C., M.D. Chicago, U.S.A.
1896. ‡*D'Henry, P.* 136 *Prince's-road, Liverpool.*
1897. ‡Dick, D. B. Toronto, Canada.
1901. ‡Dick, George Handasyde. 31 Hamilton-drive, Hillhead, Glasgow.
1901. ‡Dick, Thomas. Lochhead House, Pollokshields, Glasgow.
1889. ‡Dickinson, A. H. The Wood, Maybury, Surrey.
1863. ‡Dickinson, G. T. Lily-avenue, Jesmond, Newcastle-upon-Tyne.
1887. ‡Dickinson, Joseph, F.G.S. South Bank, Pendleton.
1904. §Dickson, Charles Scott, K.C., LL.D., M.P. Carlton Club, Pall Mall, S.W.

Year of Election.

1881. ‡Dickson, Edmund, M.A., F.G.S. 2 Starkie-street, Preston.
1887. §DICKSON, H. N., B.Sc., F.R.S.E., F.R.G S. 2 St. Margaret's-road, Oxford.
1902. §Dickson, James D. Hamilton, M.A., F.R.S.E. 6 Cranmer-road, Cambridge.
1885. ‡Dickson, Patrick. Laurencekirk, Aberdeen.
1862. *DILKE, The Right Hon. Sir CHARLES WENTWORTH, Bart., M.P., F.R.G.S. 76 Sloane-street, S.W.
1877. ‡Dillon, James, M.Inst.C.E. 36 Dawson-street, Dublin.
1901. §Dines, W. H., F.R.S. Oxshott, Leatherhead.
1900. §DIVERS, Dr. EDWARD, F.R.S. (Pres. B, 1902.) 3 Canning-place, Palace Gate, W.
1898. *Dix, John William S. Hampton Lodge, Durdham Down, Clifton, Bristol.
1905. §Dixey, F. A., M.A., M.D. Wadham College, Oxford.
1899. *DIXON, A. C., D.Sc., F.R.S. Professor of Mathematics in Queen's College, Belfast. Almora, Myrtlefield Park, Belfast.
1874. *DIXON, A. E., M.D., Professor of Chemistry in Queen's College, Cork. Mentone Villa, Sunday's Well, Cork.
1900. ‡Dixon, A. Francis, Sc.D., Professor of Anatomy in the University of Dublin.
1883. ‡Dixon, Miss E. 2 Cliff-terrace, Kendal.
1905. §Dixon, Miss E. K. 16 Mount Pleasant, Darlington.
1888. §Dixon, Edward T. Racketts, Hythe, Hampshire.
1900. *Dixon, Captain George, M.A. St. Bees, Cumberland.
1879. *DIXON, HAROLD B., M.A., F.R.S., F.C.S. (Pres. B, 1894), Professor of Chemistry in the Victoria University, Manchester.
1902. ‡Dixon, Henry H., D.Sc. 23 Northbrook-road, Dublin.
1885. ‡Dixon, John Henry. Dundarach, Pitlochry, N.B.
1887. ‡Dixon, Thomas. Buttershaw, near Bradford, Yorkshire.
1902. ‡Dixon, W. V. Scotch Quarter, Carrickfergus.
1896. §Dixon-Nuttall, F. R. Ingleholme, Eccleston Park, Prescot.
1885. ‡Doak, Rev. A. 15 Queen's-road, Aberdeen.
1890. ‡Dobbie, James J., D.Sc., F.R.S., Director of the Museum of Science and Art, Edinburgh.
1885. §Dobbin, Leonard, Ph.D. The University, Edinburgh.
1860. *Dobbs, Archibald Edward, M.A. Fylde Cottage, Branksome-avenue, Bournemouth.
1902. ‡Dobbs, F. W. 2 Willowbrook, Eton, Windsor.
1897. ‡Doberck, William. The Observatory, Hong Kong.
1892. ‡Dobie, W. Fraser. 47 Grange-road, Edinburgh.
1891. ‡Dobson, G. Alkali and Ammonia Works, Cardiff.
1905. §Dobson, Professor J. H. Transvaal Technical Institute, Johannesburg.
1876. ‡Dodds, J. M. St. Peter's College, Cambridge.
1905. §Dodds, Dr. W. J. Valkenberg, Mowbray, Cape Colony.
1897. ‡Dodge, Richard E. Teachers' College, Columbia University, New York, U.S.A.
1889. ‡Dodson, George, B.A. Downing College, Cambridge.
1898. ‡*Dole, James. Redland House, Bristol.*
1893. ‡Donald, Charles W. Kinsgarth, Braid-road, Edinburgh.
1885. ‡Donaldson, James, M.A., LL.D., F.R.S.E., Senior Principal of the University of St. Andrews, N.B.
1904. §Doncaster, Leonard. King's College, Cambridge.
1889. ‡*Donkin, R. S., M.P. Campville, North Shields.*
1896. ‡Donnan, F. E. Ardenmore-terrace, Holywood, Ireland.
1901. ‡Donnan, F. G. University College, Gower Street, W.C.

Year of Election.

1905. §Donnan, H. Allandale, Claremont, Cape Colony.
1905. §Donner, Arthur. Helsingfors, Finland.
1905. §Donovan, Surgeon-General Wm. Army Headquarters, Pretoria.
1905. §Dornan, S. S. Training Institution, Morija, Basutoland, South Africa.
1881. ‡Dorrington, John Edward. Lypiatt Park, Stroud.
1867. ‡Dougall, Andrew Maitland, R.N. Scotscraig, Tayport, Fifeshire.
1863. *Doughty, Charles Montagu. Illawara House, Tunbridge Wells.
1905. §Douglas-McMillan, Mrs. A. 31 Ford-street, Jeppestown, Transvaal.
1884. ‡Douglass, William Alexander. Freehold Loan and Savings Company, Church-street, Toronto, Canada.
1890. ‡Dovaston, John. West Felton, Oswestry.
1883. ‡Dove, Arthur. Crown Cottage, York.
1884. ‡Dove, Miss Frances. Wycombe Abbey School, Buckinghamshire.
1903. ‡Dow, Miss Agnes R. Flat 1, 27 Warrington-crescent, W.
1876. ‡Dowie, Mrs. Muir. Golland, by Kinross, N.B.
1884. *Dowling, D. J. Sycamore, Clive-avenue, Hastings.
1865. *Dowson, E. Theodore, F.R.M.S. Geldeston, near Beccles, Suffolk.
1881. *Dowson, J. Emerson, M.Inst.C.E. Merry Hall, Ashtead, Surrey.
1887. ‡Doxey, R. A. Slade House, Levenshulme, Manchester.
1894. ‡Doyne, R. W., F.R.C.S. 28 Beaumont-street, Oxford.
1883. ‡Draper, William. De Grey House, St. Leonard's, York.
1892. *Dreghorn, David, J.P. Greenwood, Pollokshields, Glasgow.
1868. ‡Dresser, Henry E., F.Z.S. 110 Cannon-street, E.C.
1905. §Drew, H. W., M.B., M.R.C.S. Mocollup Castle, Ballyduff, S.O., co. Waterford.
1890. ‡Drew, John. 12 Harringay-park, Crouch End, Middlesex, N.
1892. ‡Dreyer, John L. E., M.A., Ph.D., F.R.A.S. The Observatory, Armagh.
1893. §Druce, G. Claridge, M.A., F.L.S. (Local Sec. 1894.) 118 High-street, Oxford.
1889. ‡Drummond, Dr. 6 Saville-place, Newcastle-upon-Tyne.
1905. §Drury, H. P.O. Box 2305, Johannesburg.
1905. §Drury, Mrs. H. P.O. Box 2305, Johannesburg.
1897. ‡Drynan, Miss. Northwold, Queen's Park, Toronto, Canada.
1901. ‡Drysdale, John W. W. Bon Accord Engine Works, London-road, Glasgow.
1892. ‡*Du Bois, Dr. H. Mittelstrasse* 39, *Berlin.*
1905. §Dubois, Raymond, B.Sc. Groot Constantia, Wynberg, Cape Colony.
1905. §Dubois, Mrs. Raymond. Groot Constantia, Wynberg, Cape Colony.
1856. *Ducie, The Right. Hon. Henry John Reynolds Moreton, Earl of, F.R.S., F.G.S. 16 Portman-square, W.; and Tortworth Court, Falfield, Gloucestershire.
1870. ‡Duckworth, Henry, F.L.S., F.G.S. 7 Grey Friars, Chester.
1900. *Duckworth, W. L. H., M.A. Jesus College, Cambridge.
1895. *Duddell, William. 47 Hans-place, S.W.
1867. *Duff, The Right Hon. Sir Mountstuart Elphinstone Grant-, G.C.S.I., F.R.S., F.R.G.S. (Pres. F, 1867, 1881; Council 1868, 1892–93.) 11 Chelsea-embankment, S.W.
1904. ‡Duffield, W. G. 5 Bridge-approach, Teddington, Middlesex.
1875. ‡Duffin, W. E. L'Estrange. Waterford.
1890. ‡Dufton, S. F. Trinity College, Cambridge.
1884. ‡Dugdale, James H. 9 Hyde Park-gardens, W.
1883. ‡Duke, Frederic. Conservative Club, Hastings.
1891. *Duncan, John, J.P. 'South Wales Daily News' Office, Cardiff.
1896. ‡Duncanson, Thomas. 16 Deane-road, Liverpool.
1893. *Dunell, George Robert. 33 Spencer-road, Grove Park, Chiswick, W.
1892. ‡Dunham, Miss Helen Bliss. Messrs. Morton, Rose, & Co., Bartholomew House, E.C.

Year of Election.

1896. *DUNKERLEY, STANLEY, D.Sc., M.Inst.C.E., Professor of Engineering in the Victoria University, Manchester.
1865. ‡Dunn, David. Annet House, Skelmorlie, by Greenock, N.B.
1876. ‡Dunnachie, James. 48 West Regent-street, Glasgow.
1884. §Dunnington, Professor F. P. University of Virginia, Charlottesville, Virginia, U.S.A.
1859. ‡Duns, Rev. John, D.D., F.R.S.E. New College, Edinburgh.
1893. *Dunstan, M. J. R., Principal of the South-Eastern Agricultural College, Wye, Kent.
1891. ‡Dunstan, Mrs. South-Eastern Agricultural College, Wye, Kent.
1885. *DUNSTAN, Professor WYNDHAM, M.A., LL.D., F.R.S., V.P.C.S. (Council 1905–), Director of the Imperial Institute, S.W.
1869. ‡D'Urban, W. S. M. Newport House, near Exeter.
1898. ‡Durrant, R. G. Marlborough College, Wilts.
1905. §Dutton, C. L. O'Brien. High Commissioner's Office, Johannesburg.
1895. *DWERRYHOUSE, ARTHUR R., M.Sc., F.G.S. 5 Oakfield-terrace, Headingley, Leeds.
1884. ‡Dyck, Professor Walter. The University, Munich.
1885. *Dyer, Henry, M.A., D.Sc. 8 Highburgh-terrace, Dowanhill, Glasgow.
1895. §Dymond, Thomas S., F.C.S. County Technical Laboratory, Chelmsford, Essex.
1905. §DYSON, F. W., M.A., F.R.S. (Council 1905–), Astronomer Royal for Scotland and Professor of Practical Astronomy in the University of Edinburgh.

1868. ‡Eade, Sir Peter, M.D. Upper St. Giles's street, Norwich.
1895. ‡Earle, Hardman A. Salford Iron Works, Manchester.
1877. ‡Earle, Ven. Archdeacon, M.A. West Alvington, Devon.
1905. §Earp, E. J. P.O. Box 538, Cape Town.
1874. ‡Eason, Charles. 30 Kenilworth-square, Rathgar, Dublin.
1899. §East, W. H. Municipal School of Art, Science, and Technology, Dover.
1871. *EASTON, EDWARD. (Pres. G, 1878; Council 1879–81.) 22 Vincent-square, Westminster, S.W.
1863. ‡Easton, James. Nest House, near Gateshead, Durham.
1876. ‡Easton, John. Durie House, Abercromby-street, Helensburgh, N.B.
1883. ‡Eastwood, Miss. Littleover Grange, Derby.
1893. *Ebbs, Alfred B. Northumberland-alley, Fenchurch-street, E.C.
1905. §Ebden, Hon. Alfred. Belmont, Rondebosch, Cape Colony.
1903. ‡*Eccles, W. H., D.Sc. 1 Owen's-mansions, Queen's Club-gardens, West Kensington, W.*
1884. ‡Eckersley, W. T. Standish Hall, Wigan, Lancashire.
1861. ‡Ecroyd, William Farrer. Spring Cottage, near Burnley.
1870. *Eddison, John Edwin, M.D., M.R.C.S. The Lodge, Adel, Leeds.
1899. ‡Eddowes, Alfred, M.D. 28 Wimpole-street, W.
*Eddy, James Ray, F.G.S. The Grange, Carleton, Skipton.
1887. ‡Ede, Francis J., F.G.S. Silchar, Cachar, India.
1884. *Edgell, Rev. R. Arnold, M.A., F.C.S. Sywell House, Llandudno.
1887. §EDGEWORTH, F. Y., M.A., D.C.L., F.S.S. (Pres. F, 1889; Council 1879–86, 1891–98), Professor of Political Economy in the University of Oxford. All Souls College, Oxford.
1870. *Edmonds, F. B. 6 Clement's Inn, W.C.
1883. ‡Edmonds, William. Wiscombe Park, Colyton, Devon.
1888. *Edmunds, Henry. Antron, 71 Upper Tulse-hill, S.W.

Year of Election.

1884. *Edmunds, James, M.D. 4 Chichester-terrace, Kemp Town, Brighton.
1883. ‡Edmunds, Lewis, D.Sc., LL.M., F.G.S. 1 Garden-court, Temple, E.C.
1901. *Edridge-Green, F. W., M.D., F.R.C.S. St. John's College, Cambridge.
1905. §Edwards, Bidewell. 80 St. George's-street, Cape Town.
1899. §Edwards, E. J., Assoc.M.Inst.C.E. 232 Trinity-road, Wandsworth, S.W.
1903. ‡Edwards, Mrs. Emily. Norley Grange, 73 Leyland-road, Southport.
1903. ‡Edwards, Francis. Norley Grange, 73 Leyland-road, Southport.
1903. ‡Edwards, Miss Marion K. Norley Grange, 73 Leyland-road, Southport.
1887. *Egerton of Tatton, The Right Hon. Lord. Tatton Park, Knutsford.
1901. ‡Eggar, W. D. Willowbrook, Eton, Windsor.
1896. ‡Ekkert, Miss Dorothea. 95 Upper Parliament-street, Liverpool.
1876. ‡Elder, Mrs. 6 Claremont-terrace, Glasgow.
1890. §Elford, Percy. St. John's College, Oxford.
1885. *Elgar, Francis, LL.D., F.R.S., F.R.S.E., M.Inst.C.E. 34 Leadenhall-street, E.C.
1904. §Eliot, Sir John, K.C.I.E., M.A., F.R.S. 79 Alleyn-park, Dulwich, S.E.
1901. *Elles, Miss Gertrude L. Newnham College, Cambridge.
1883. ‡Ellington, Edward Bayzand, M.Inst.C.E. Palace-chambers, Bridge-street, Westminster, S.W.
1904. §Elliot, Miss Agnes I. M. Newnham College, Cambridge.
1904. §Elliot, R. H. Clifton Park, Kelso, N.B.
1886. ‡Elliot, Sir Thomas Henry, K.C.B., F.S.S. Board of Agriculture, 4 Whitehall-place, S.W.
1904. ‡Elliot, T. R. B. Holme Park, Rotherfield, Sussex.
1891. ‡Elliott, A. C., D.Sc., Professor of Engineering in University College, Cardiff. 2 Plasturton-avenue, Cardiff.
1905. §Elliott, C. C., M.D. 5 Bureau-street, Cape Town.
1883. *Elliott, Edwin Bailey, M.A., F.R.S., F.R.A.S., Waynflete Professor of Pure Mathematics in the University of Oxford. 4 Bardwell-road, Oxford.
Elliott, John Fogg. Elvet Hill, Durham.
1875. *Ellis, H. D. 12 Gloucester-terrace, Hyde Park, W.
1880. *Ellis, John Henry (Local Sec. 1883.) 3 Carlisle-terrace, The Hoe, Plymouth.
1891. §Ellis, Miss M. A. 129 Walton-street, Oxford.
1884. ‡Ellis, Professor W. Hodgson, M.A., M.B. 74 St. Alban's-street, Toronto, Canada.
Ellman, Rev. E. B. Berwick Rectory, near Lewes, Sussex.
1887. ‡Elmy, Ben. Congleton, Cheshire.
1862. ‡Elphinstone, Sir H. W., Bart., M.A., F.L.S. 2 Stone-buildings, Lincoln's Inn, W.C.
1897. §Elvery, Mrs. Elizabeth. The Cedars, Maison Dieu-road, Dover.
1883. ‡Elwes, Captain George Robert. Bossington, Bournemouth.
1887. §Elworthy, Frederick T., F.S.A. Foxdown, Wellington, Somerset.
1904. ‡Ely, The Right Rev. F. H. Chase, D.D., Lord Bishop of. The Palace, Ely, Cambridgeshire.
1897. ‡Ely, Robert E. 23 West 44th-street, New York, U.S.A.
1891. ‡Emerton, Wolseley, D.C.L. Banwell Castle, Somerset.
1884. ‡Emery, Albert H. Stamford, Connecticut, U.S.A.
1863. ‡Emery, The Ven. Archdeacon, B.D. Ely, Cambridgeshire.
1894. ‡Emtage, W. T. A., Director of Public Instruction, Mauritius.

Year of Election.

1866. ‡Enfield, Richard. Low Pavement, Nottingham.
1884. ‡England, Luther M. Knowlton, Quebec, Canada.
1853. ‡English, E. Wilkins. Yorkshire Banking Company, Lowgate, Hull.
1869. *Enys, John Davis. Enys, Penryn, Cornwall.
1894. ‡Erskine-Murray, James, D.Sc., F.R.S.E. University College, Nottingham.
1862. *Esson, William, M.A., F.R.S., F.R.A.S., Savilian Professor of Geometry in the University of Oxford. 13 Bradmore-road, Oxford.
1887. *Estcourt, Charles, F.I.C. 5 Seymour-grove, Old Trafford, Manchester.
1887. *Estcourt, P. A., F.C.S., F.I.C. 5 Seymour-grove, Old Trafford, Manchester.
1901. ‡*Ettersbank, John. Care of Messrs. Dalgety & Co., 52 Lombard-street, E.C.*
1889. *Evans, A. H., M.A. 9 Harvey-road, Cambridge.
1905. §Evans, Mrs. A. H. 9 Harvey-road, Cambridge.
1870. *Evans, Arthur John, M.A., LL.D., F.R.S., F.S.A. (Pres. H, 1896.) Youlbury, Abingdon.
1865. *Evans, Rev. Charles, M.A. Parkstone, Dorset.
1896. ‡Evans, Edward, jun. Spital Old Hall, Bromborough, Cheshire.
1889. ‡Evans, Henry Jones. Greenhill, Whitchurch, Cardiff.
1887. *Evans, Mrs. Isabel. Hoghton Hall, Hoghton, near Preston.
1883. *Evans, Mrs. James C. 38 Crescent-road, Birkdale, Southport.
1861. *Evans, Sir John, K.C.B., D.C.L., LL.D., D.Sc., F.R.S., F.S.A., F.L.S., F.G.S. (President, 1897; Pres. C, 1878; Pres. H, 1890; Council 1868-74, 1875-82, 1889-96.) Nash Mills, Hemel Hempstead.
1897. *Evans, Lady. Nash Mills, Hemel Hempstead.
1898. ‡Evans, Jonathan L. 4 Litfield-place, Clifton, Bristol.
1881. ‡Evans, Lewis. Llanfyrnach, R.S.O., Pembrokeshire.
1885. *Evans, Percy Bagnall. The Spring, Kenilworth.
1905. §Evans, R. O. Ll. Broom Hall, Chwilog, R.S.O., Carnarvonshire.
1865. ‡Evans, Sebastian, M.A., LL.D. Abbot's Barton, Canterbury.
1899. ‡Evans, Mrs. Abbot's Barton, Canterbury.
1905. §Evans, T. H. 9 Harvey-road, Cambridge.
1905. §Evans, Thomas H. P.O. Box 1276, Johannesburg.
1865. *Evans, William. The Spring, Kenilworth.
1903. ‡Evatt, E. J., M.B. 8 Kyveilog-street, Cardiff.
1871. ‡Eve, H. Weston, M.A. 37 Gordon-square, W.C.
1902. *Everett, Percy W. Oaklands, Elstree, Hertfordshire.
1895. ‡Everett, W. H., B.A. University College, Nottingham.
1863. *Everitt, George Allen, F.R.G.S. Knowle Hall, Warwickshire.
1886. ‡*Everitt, William E. Finstall Park, Bromsgrove.*
1883. ‡Eves, Miss Florence. Uxbridge.
1881. ‡Ewart, J. Cossar, M.D., F.R.S. (Pres. D, 1901), Professor of Natural History in the University of Edinburgh.
1874. ‡Ewart, Sir W. Quartus, Bart. (Local Sec. 1874.) Glenmachan, Belfast.
1876. *Ewing, James Alfred, M.A., LL.D., F.R.S., F.R.S.E., M.Inst. C.E., Director of Naval Education, Admiralty, S.W.
1883. ‡Ewing, James L. 52 North Bridge, Edinburgh.
1903. §Ewing, Peter, F.L.S. The Frond, Uddingston, Glasgow.
1884. *Eyerman, John, F.Z.S. Oakhurst, Easton, Pennsylvania, U.S.A.
1882. ‡Eyre, G. E. Briscoe. Warrens, near Lyndhurst, Hants.
1905. §Eyre, Dr. G. G. Claremont, Cape Colony.
Eyton, Charles. Hendred House, Abingdon.

Year of Election.

1890. ‡Faber, Edmund Beckett. Straylea, Harrogate.
1896. ‡Fairbrother, Thomas. 46 Lethbridge-road, Southport.
1901. §Fairgrieve, M. McCallum. 115 Dalkeith-road, Edinburgh.
1865. *Fairley, Thomas, F.R.S.E., F.C.S. 8 Newton-grove, Leeds.
1896. §Falk, Herman John, M.A. Thorshill, West Kirby, Cheshire.
1902. §Fallaize, E. N., M.A. 25 Alexandra-mansions, Middle-lane, Hornsey, N.
1898. ‡Faraday, Miss Ethel R., M.A. Ramsay Lodge, Levenshulme, near Manchester.
1877. §Faraday, F. J., F.L.S., F.S.S. (Local Sec. 1887.) College-chambers, 17 Brazennose-street, Manchester.
1902. §Faren, William. 11 Mount Charles, Belfast.
1892. *Farmer, J. Bretland, M.A., F.R.S., F.L.S., Professor of Botany, Royal College of Science, Exhibition-road, S.W.
1886. ‡Farncombe, Joseph, J.P. Saltwood, Spencer-road, Eastbourne.
1897. *Farnworth, Ernest. Broadlands, Goldthorn Hill, Wolverhampton.
1897. *Farnworth, Mrs. Ernest. Broadlands, Goldthorn Hill, Wolverhampton.
1904. §Farnworth, Miss Olive. Broadlands, Goldthorn Hill, Wolverhampton.
1883. ‡Farnworth, William. 86 Preston New-road, Blackburn.
1885. ‡Farquhar, Admiral. Carlogie, Aberdeen.
1885. *Farquharson, Mrs. R. F. O. Tillydrine, Kincardine O'Neil, N.B.
1905. §Farrar, Edward. P.O. Box, 4181 Johannesburg.
1883. ‡Farrell, John Arthur. Moynalty, Kells, North Ireland.
1904. §Farrer, Sir William. 18 Upper Brook-street, W.
1897. ‡Farthing, Rev. J. C., M.A. The Rectory, Woodstock, Ontario, Canada.
1883. ‡Faulding, Mrs. Boxley House, Tenterden, Kent.
1903. §Faulkner, Joseph M. 13 Great Ducie-street, Strangeways, Manchester.
1890. *Fawcett, F. B. University College, Bristol.
1900. ‡Fawcett, J. E., J.P. (Local Sec. 1900.) Low Royd, Apperley Bridge, Bradford.
1902. *Fawsitt, C. E., Ph.D. 9 Foremount-terrace, Dowanhill, Glasgow.
1901. *Fearnsides, W. G., B.A., F.G.S. Sidney Sussex College, Cambridge.
1905. §Feilden, Colonel H. W., C.B. Burwash, Sussex.
1886. ‡*Felkin, Robert W., M.D., F.R.G.S. 48 Westbourne-gardens, Bayswater, W.*
1900. *Fennell, William John. Deramore Drive, Belfast.
1904. ‡Fenton, H. J. H., M.A., F.R.S. 19 Brookside, Cambridge.
1883. ‡Fenwick, E. H. 29 Harley-street, W.
1890. ‡Fenwick, T. Chapel Allerton, Leeds.
1876. ‡Ferguson, Alexander A. 11 Grosvenor-terrace, Glasgow.
1883. ‡Ferguson, Mrs. A. A. 11 Grosvenor-terrace, Glasgow.
1902. ‡Ferguson, Godfrey W. (Local Sec. 1902.) Cluan, Donegall Park, Belfast.
1871. *Ferguson, John, M.A., LL.D., F.R.S.E., F.S.A., F.C.S., Professor of Chemistry in the University of Glasgow.
1896. *Ferguson, John. Calton Lodge, Cinnamon-gardens, Colombo, Ceylon.
1901. ‡Ferguson, R. W. Municipal Technical School, The Gamble Institute, St. Helens, Lancashire.
1867. ‡Ferguson, Robert M., LL.D., Ph.D., F.R.S.E. 5 Learmonth-terrace, Edinburgh.
1883. ‡Fernald, H. P. Clarence House, Promenade, Cheltenham.
1883. *Fernie, John. Box No. 2, Hutchinson, Kansas, U.S.A.

Year of Election.

1905. *Ferrar, H. T. Survey Department, Cairo.
1905. §Ferrar, J. E. Sidney Sussex College, Cambridge.
1873. ‡FERRIER, DAVID, M.A., M.D., LL.D., F.R.S., Professor of Neuro-Pathology in King's College, London. 34 Cavendish-square, W.
1892. ‡Ferrier, Robert M., B.Sc., Professor of Engineering, University College, Bristol.
1897. ‡Fessenden, Reginald A., Professor of Electrical Engineering, University, Alleghany, Pennsylvania, U.S.A.
1882. §Fewings, James, B.A., B.Sc. . King Edward VI. Grammar School, Southampton.
1887. ‡Fiddes, Thomas, M.D. Penwood, Urmston, near Manchester.
1875. ‡Fiddes, Walter. Clapton Villa, Tyndall's Park, Clifton, Bristol.
1868. ‡Field, Edward. Norwich.
1897. ‡Field, George Wilton, Ph.D. Experimental Station, Kingston, Rhode Island, U.S.A.
1882. ‡Filliter, Freeland. St. Martin's House, Wareham, Dorset.
1883. *Finch, Gerard B., M.A. 1 St. Peter's-terrace, Cambridge.
1905. §Fincham, G. H. South African College, Cape Town.
1878. *Findlater, Sir William. 22 Fitzwilliam-square, Dublin.
1905. §Findlay, Alexander, M.A., Ph.D., D.Sc., Lecturer on Physical Chemistry in the University of Birmingham.
1904. *Findlay, J. J., Ph.D., Professor of Education in the University of Manchester.
1902. §Finnegan, J., B.A., B.Sc. Kelvin House, Botanic-avenue, Belfast.
1887. ‡Finnemore, Rev. J., M.A., Ph.D., F.G.S. Hawkhurst, Four Oaks, Sutton Coldfield.
1881. ‡Firth, Colonel Sir Charles. Heckmondwike.
1895. §Fish, Frederick J. Spursholt, Park-road, Ipswich.
1891. ‡Fisher, Major H. O. The Highlands, Llandough, near Cardiff.
1902. ‡Fisher, J. R. Cranfield, Fortwilliam Park, Belfast.
1884. *Fisher, L. C. Galveston, Texas, U.S.A.
1869. ‡FISHER, Rev. OSMOND, M.A., F.G.S. Harlton Rectory, near Cambridge.
1875. *Fisher, W. W., M.A., F.C.S. 5 St. Margaret's-road, Oxford.
1858. ‡Fishwick, Henry. Carr-hill, Rochdale.
1887. *Fison, Alfred H., D.Sc. 47 Dartmouth-road, Willesden Green, N.W.
1885. ‡Fison, E. Herbert. Stoke House, Ipswich.
1871. *FISON, Sir FREDERICK W., Bart., M.A., M.P., F.C.S. 64 Pont-street, S.W.
1883. ‡Fitch, Rev. J. J. 5 Chambres-road, Southport.
1878. ‡Fitzgerald, C. E., M.D. 27 Upper Merrion-street, Dublin.
1885. *FITZGERALD, Professor MAURICE, B.A. (Local Sec. 1902.) 32 Eglantine-avenue, Belfast.
1894. ‡Fitzmaurice, M., C.M.G., M.Inst.C.E. London County Council, Spring-gardens, S.W.
1888. *FITZPATRICK, Rev. THOMAS C. Christ's College, Cambridge.
1904. ‡Flather, J. H., M.A. Camden House, 90 Hills-road, Cambridge.
1897. ‡Flavelle, J. W. 565 Jarvis-street, Toronto, Canada.
1881. ‡Fleming, Rev. Canon J., B.D. St. Michael's Vicarage, Ebury-square, S.W.
1904. §Fleming, James. 198 York-street, Belfast.
1876. ‡Fleming, James Brown. Beaconsfield, Kelvinside, Glasgow.
1876. ‡Fleming, Sir Sandford, K.C.M.G., F.G.S. Ottawa, Canada.
1870. ‡Fletcher, B. Edgington. Marlingford Hall, Norwich.
1890. ‡Fletcher, B. Morley. 7 Victoria-street, S.W.
1892. ‡Fletcher, George, F.G.S. Dawson Court, Blackrock, co. Dublin.

Year of Election.

1888. *FLETCHER, LAZARUS, M.A., F.R.S., F.G.S., F.C.S. (Pres. C, 1894), Keeper of Minerals, British Museum (Natural History), Cromwell-road, S.W. 35 Woodville-gardens, Ealing, W.
1901. ‡Flett, J. S., M.A., D.Sc., F.R.S.E. 28 Jermyn-street, S.W.
1905. *Flint, Rev. W., D.D. Houses of Parliament, Cape Town.
1889. ‡Flower, Lady. 26 Stanhope-gardens, S.W.
1905. §Flowers, Frank. United Buildings, Foxburgh, Johannesburg.
1890. *FLUX, A. W., M.A., Professor of Political Economy in McGill University, Montreal, Canada.
1877. ‡Foale, William. The Croft, Madeira Park, Tunbridge Wells.
1891. ‡Foldvary, William. Museum Ring, 10, Buda Pesth.
1903. §Foord-Kelcey, W., Professor of Mathematics in the Royal Military Academy, Woolwich. The Shrubbery, Shooter's Hill, S.E.
1880. ‡Foote, R. Bruce, F.G.S. Care of Messrs. H. S. King & Co., 65 Cornhill, E.C.
1885. ‡Forbes, The Right Hon. Lord. Castle Forbes, Aberdeenshire.
1873. *FORBES, GEORGE, M.A., F.R.S., F.R.S.E., M.Inst.C.E. 34 Great George-street, S.W.
1883. ‡FORBES, HENRY O., LL.D., F.Z.S., Director of Museums for the Corporation of Liverpool. The Museum, Liverpool.
1897. ‡Forbes, J., K.C. Hazeldean, Putney-hill, S.W.
1905. §FORBES, Major W. LACHLAN, Sec.R.Scot.G.S. Queen-street, Edinburgh.
1890. ‡FORD, J. RAWLINSON (Local Sec. 1890). Quarry Dene, Weetwood-lane, Leeds.
1875. *FORDHAM, H. GEORGE. Odsey, Ashwell, Baldock, Herts.
1887. ‡FORREST, The Right Hon. Sir JOHN, G.C.M.G., F.R.G.S., F.G.S. Perth, Western Australia.
1902. §Forster, M. O., Ph.D., D.Sc., F.R.S. Royal College of Science, S.W.
1883. ‡FORSYTH, A. R., M.A., D.Sc., F.R.S. (Pres. A, 1897, 1905), Sadlerian Professor of Pure Mathematics in the University of Cambridge. Trinity College, Cambridge.
1900. ‡Forsyth, D. Central Higher Grade School, Leeds.
1884. ‡Fort, George H. Lakefield, Ontario, Canada.
1896. ‡FORWOOD, Sir WILLIAM B., J.P. Ramleh, Blundellsands, Liverpool.
1865. ‡Foster, Sir B. Walter, M.D., M.P. 16 Temple-row, Birmingham.
1883. ‡Foster, Lady. 86 Coleherne-court, Earl's Court, S.W.
1857. *FOSTER, GEORGE CAREY, B.A., LL.D., D.Sc., F.R.S. (GENERAL TREASURER, 1898–1904; Pres. A, 1877; Council 1871–76, 1877–82.) Ladywalk, Rickmansworth.
1896. ‡Foster, Miss Harriet. Cambridge Training College, Wollaston-road, Cambridge.
1859. *FOSTER, Sir MICHAEL, K.C.B., M.P., M.A., M.D., LL.D., D.C.L., F.R.S., F.L.S. (PRESIDENT, 1899; GEN. SEC. 1872–76; Pres. I, 1897; Council, 1871–72). Great Shelford, Cambridge.
1901. §Foster, T. Gregory, Ph.D., Principal of University College, W.C. Chester-road, Northwood, Middlesex.
1903. §Fourcade, H. G. P. O., Storms River, Humansdorp, Cape Colony.
1896. ‡Fowkes, F. Hawkshead, Ambleside.
1905. §Fowlds, Hiram. Keighley, Yorkshire.
1868. ‡Fowler, G. G. Gunton Hall, Lowestoft, Suffolk.
1866. ‡Fowler, George, M.Inst.C.E., F.G.S. Basford Hall, near Nottingham.
1892. ‡Fowler, Miss Jessie A. 4 & 5 Imperial-buildings, Ludgate-circus, E.C.
1901. ‡Fowlis, William. 45 John-street, Glasgow.
1883. *Fox, Charles. The Pynes, Warlingham-on-the-Hill, Surrey.
1883. §Fox, Sir CHARLES DOUGLAS, M.Inst.C.E. (Pres. G, 1896.) 28 Victoria-street, Westminster, S.W.

Year of Election.

1904. *Fox, Charles J. J., B.Sc., Ph.D. 33 Ashley-road, Crouch Hill, N.
1904. §Fox, F. Douglas, M.A., M.Inst.C.E. 19 The Square, Kensington, W.
1905. §Fox, Mrs. F. Douglas. 19 The Square, Kensington, W.
1896. ‡Fox, Henry J. Bank's Dale, Bromborough, near Liverpool.
1883. ‡Fox, Howard, F.G.S. Rosehill, Falmouth
1847. *Fox, Joseph Hoyland. The Clive, Wellington, Somerset.
1900. *Fox, Thomas. Pyles Thorne House, Wellington, Somerset.
1881. *FOXWELL, HERBERT S., M.A., F.S.S. (Council 1894–97), Professor of Political Economy in University College, London. St. John's College, Cambridge.
1905. §Frames, Henry J. Talana, St. Patrick's-avenue, Parktown, Johannesburg.
1905. §Frames, Mrs. Talana, St. Patrick's-avenue, Parktown, Johannesburg.
1889. ‡Frain, Joseph, M.D. Grosvenor-place, Jesmond, Newcastle-upon-Tyne.
1905. §Francke, M. P.O. Box 1156, Johannesburg.
1887. *FRANKLAND, PERCY F., Ph.D., B.Sc., F.R.S. (Pres. B, 1901), Professor of Chemistry in the University of Birmingham.
1894. ‡Franklin, Mrs. E. L. 50 Porchester-terrace, W.
1895. §Fraser, Alexander. 63 Church-street, Inverness.
1882. *Fraser, Alexander, M.B., Professor of Anatomy in the Royal College of Surgeons, Dublin.
1885. ‡FRASER, ANGUS, M.A., M.D., F.C.S. (Local Sec. 1885.) 232 Union-street, Aberdeen.
1892. ‡Fraser, Mrs. J. G. 4 Parkside, Cambridge.
1865. *FRASER, JOHN, M.A., M.D., F.G.S. Chapel Ash, Wolverhampton.
1871. ‡FRASER, Sir THOMAS R., M.D., F.R.S., F.R.S.E., Professor of Materia Medica and Clinical Medicine in the University of Edinburgh. 13 Drumsheugh-gardens, Edinburgh.
1871. ‡Frazer, Evan L. R. Brunswick-terrace, Spring Bank, Hull.
1884. *Frazer, Persifor, M.A., D.Sc. (Univ. de France). Room 1042 Drexel Building, Philadelphia, U.S.A.
1884. *FREAM, W., LL.D., B.Sc., F.L.S., F.G.S., F.S.S. The Vinery, Downton, Salisbury.
1877. §Freeman, Francis Ford. Abbotsfield, Tavistock, South Devon.
1884. *FREMANTLE, The Hon. Sir C. W., K.C.B. (Pres. F, 1892; Council 1897–1903.) 4 Lower Sloane-street, S.W.
1905. §French, Sir Somerset R., K.C.M.G. Erritt Lodge, Kenilworth, Cape Colony.
1886. ‡FRESHFIELD, DOUGLAS W., F.R.G.S. (Pres. E. 1904.) 1 Airlie-gardens, Campden Hill, W.
1901. ‡Frew, William, Ph.D. King James-place, Perth.
1887. ‡Fries, Harold H., Ph.D. 92 Reade-street, New York, U.S.A.
1892. *Frost, Edmund, M.B. Chesterfield-road, Eastbourne.
1882. §Frost, Edward P., J.P. West Wratting Hall, Cambridgeshire.
1887. *Frost, Robert, B.Sc. 55 Kensington Court, W.
1899. ‡Fry, Edward W. Cannon-street, Dover.
1890. ‡FRY, The Right Hon. Sir EDWARD, D.C.L., LL.D., F.R.S., F.S.A. Failand House, Failand, near Bristol.
1898. ‡*Fry, Francis J. Leigh Woods, Clifton, Bristol.*
1905. §Fry, H. P.O. Box 46, Johannesburg.
1875. *Fry, Joseph Storrs. 16 Upper Belgrave-road, Clifton, Bristol.
1905. *Fry, William, jun., J.P., F.R.G.S. Wilton House, Merrion-road, Dublin.
1898. ‡Fryer, Alfred C., Ph.D. 13 Eaton-crescent, Clifton, Bristol.
1895. ‡FULLARTON, Dr. J. H. Fishery Board for Scotland, George-street, Edinburgh.

Year of Election.

1872. *Fuller, Rev. A. 7 Sydenham-hill, Sydenham, S.E.
1859. ‡FULLER, FREDERICK, M.A. (Local Sec. 1859.) 9 Palace-road, Surbiton.
1869. ‡FULLER, G., M.Inst.C.E. (Local Sec. 1874.) 71 Lexham-gardens, Kensington, W.

1887. ‡Gaddum, G. H. Adria House, Toy-lane, Withington, Manchester
1863. *Gainsford, W. D. Skendleby Hall, Spilsby.
1896. ‡Gair, H. W. 21 Water-street, Liverpool.
1850. ‡GAIRDNER, Sir W. T., K.C.B., M.D., LL.D., F.R.S. 32 George-square, Edinburgh.
1885 *Gallaway, Alexander. Dirgarve, Aberfeldy, N.B.
1875. ‡GALLOWAY, W. Cardiff.
1887. *Galloway, W. J., M.P. The Cottage, Seymour-grove, Old Trafford, Manchester.
1889. ‡Galloway, Walter. Eighton Banks, Gateshead.
1905. §Galpin, Ernest E. Bank of Africa, Queenstown, Cape Colony.
1905. §Galpin, Mrs. E. E. Bank of Africa, Queenstown, Cape Colony.
1899. §Galton, Lady Douglas. Himbleton Manor, Droitwich.
1860. *GALTON, FRANCIS, M.A., D.C.L., D.Sc., F.R.S., F.R.G.S. (GEN. SEC. 1863–68; Pres. E, 1862, 1872; Pres. H, 1885; Council 1860–63). 42 Rutland-gate, Knightsbridge, S.W.
1870. §Gamble, Lieut.-Colonel Sir D., Bart., K.C.B. St. Helens, Lancashire.
1889. ‡Gamble, David. Ratonagh, Colwyn Bay.
1870. ‡Gamble, J. C. St. Helens, Lancashire.
1888. *GAMBLE, J. SYKES, C.I.E., M.A., F.R.S., F.L.S. Highfield, East Liss, Hants.
1877. ‡Gamble, William. St. Helens, Lancashire.
1868. ‡GAMGEE, ARTHUR, M.D., F.R.S. (Pres. D, 1882; Council 1888–90). 5 Avenue du Kursaal, Montreux, Switzerland.
1899. *Garcke, E. Ditton House, near Maidenhead.
1898. ‡Garde, Rev. C. L. Skenfrith Vicarage, near Monmouth.
1905. §Gardiner, J. H. 59 Wroughton-road, Balham, S.W.
1900. ‡Gardiner, J. Stanley, M.A. Dunstall, Newton-road, Cambridge.
1887. ‡GARDINER, WALTER, M.A., D.Sc., F.R.S. St. Awdreys, Hills-road, Cambridge.
1882. *Gardner, H. Dent, F.R.G.S. Fairmead, 46 The Goffs, Eastbourne.
1896. ‡Gardner, James. The Groves, Grassendale, Liverpool.
1882. ‡*GARDNER, JOHN STARKIE. 29 Albert Embankment, S.E.*
1905. §Garlick, John. Cape Town.
1905. §Garlick, R. C. Thornibrae, Green Point, Cape Town.
1887. *Garnett, Jeremiah. The Grange, Bromley Cross, near Bolton, Lancashire.
1882. ‡Garnett, William, D.C.L. London County Council, Spring-gardens, S.W.
1873. ‡Garnham, John. Hazelwood, Crescent-road, St. John's, Brockley, Kent, S.E.
1883. ‡GARSON, J. G., M.D. (ASSIST. GEN. SEC. 1902–04.) Moorcote, Eversleigh, Winchfield.
1903. ‡Garstang, A. H. 20 Roe-lane, Southport.
1903. *Garstang, T. James, M.A. Bedale's School, Petersfield, Hampshire.
1894. *GARSTANG, WALTER, M.A., F.Z.S. Marine Biological Laboratory, Lowestoft.
1874. *Garstin, John Ribton, M.A., LL.B., M.R.I.A., F.S.A. Bragans-town, Castlebellingham, Ireland.
1905. §Garthwaite, E. H. B.S.A.Co., Bulawayo, South Africa.
1882. ‡Garton, William. Woolston, Southampton.

Year of
Election.

1892. ‡*Garvie, James. Bolton's Park, Potter's Bar.*
1889. ‡Garwood, Professor E. J., M.A., F.G.S. University College, Gower-street, W.C.
1905. §Gaskell, Miss C. J. The Uplands, Great Shelford, Cambridge.
1870. *Gaskell, Holbrook. Erindale, Frodsham, Cheshire.
1905. §Gaskell, Miss M. A. The Uplands, Great Shelford, Cambridge.
1896. *Gaskell, Walter Holbrook, M.A., M.D., LL.D., F.R.S. (Pres. I, 1896; Council 1898–1901.) The Uplands, Great Shelford, Cambridge.
1896. ‡Gatehouse, Charles. Westwood, Noctorum, Birkenhead.
1905. §Gaughren, Right Rev. Dr. M. Dutoitspan-road, Kimberley.
1875. ‡Gavey, J. Hollydale, Hampton Wick, Middlesex.
1905. *Gearon, Miss Susan. 55 Buckleigh-road, Streatham Common, S.W.
1892. ‡Geddes, George H. 8 Douglas-crescent, Edinburgh.
1871. ‡Geddes, John. 9 Melville-crescent, Edinburgh.
1885. ‡Geddes, Professor Patrick. Ramsay-garden, Edinburgh.
1867. ‡Geikie, Sir Archibald, LL.D., D.Sc., Sec.R.S., F.R.S.E., F.G.S. (President, 1892; Pres. C, 1867, 1871, 1899; Council 1888–91.) 3 Sloane Court, S.W.
1871. ‡Geikie, James, LL.D., D.C.L., F.R.S., F.R.S.E., F.G.S. (Pres. C, 1889; Pres. E, 1892), Murchison Professor of Geology and Mineralogy in the University of Edinburgh. Kilmorie, Colinton-road, Edinburgh.
1898. §Gemmill, James F., M.A., M.D. 21 Endsleigh-gardens, Partickhill, Glasgow.
1882. *Genese, R. W., M.A., Professor of Mathematics in University College, Aberystwyth.
1905. §Gentleman, Miss A. A. 9 Abercromby-place, Stirling.
1875. *George, Rev. Hereford Brooke, M.A., F.R.G.S. Holywell Lodge, Oxford.
1902. *Gepp, Antony, M.A., F.L.S. British Museum (Natural History), Cromwell-road, S.W.
1899. *Gepp, Mrs. A. 26 West Park-gardens, Kew.
1885. ‡*Gerard, Robert. Blair-Devenick, Cults, Aberdeen.*
1884. *Gerrans, Henry T., M.A. 20 St. John-street, Oxford.
1905. §Gibbs, Miss Lilian S., F.L.S. 9 South-street, Thurloe-square, S.W.
1902. ‡Gibson, Andrew. 14 Cliftonville-avenue, Belfast.
1874. ‡Gibson, The Right Hon. Edward, K.C. 23 Fitzwilliam-square, Dublin.
1892. ‡Gibson, Francis Maitland. Care of Professor Gibson, 20 George-square, Edinburgh.
1901. §Gibson, Professor George A., M.A. 8 Sandyford-place, Glasgow.
1876. *Gibson, George Alexander, M.D., D.Sc., LL.D., F.R.S.E. 3 Drumsheugh-gardens, Edinburgh.
1892. ‡Gibson, James. 20 George-square, Edinburgh.
1884. ‡Gibson, Rev. James J. 183 Spadina-avenue, Toronto, Canada.
1904. *Gibson, Mrs. Margaret D. Castle Brae, Chesterton-road, Cambridge.
1896. ‡Gibson, R. J. Harvey, M.A., F.R.S.E., Professor of Botany in the University of Liverpool.
1889. *Gibson, T. G. Lesbury House, Lesbury, R.S.O., Northumberland.
1893. ‡Gibson, Walcot, F.G.S. 28 Jermyn-street, S.W.
1887. *Giffen, Sir Robert, K.C.B., LL.D., F.R.S., V.P.S.S. (Pres. F, 1887, 1901.) Chanctonbury, Hayward's Heath.
1898. *Gifford, J. William. Oaklands, Chard.
1884. ‡Gilbert E. E. 245 St. Antoine-street, Montreal, Canada.
1857. ‡Gilbert, J. T., M.R.I.A. Villa Nova, Blackrock, Dublin.
1883. §Gilbert, Lady. Englefield Green, Surrey.
1884. *Gilbert, Philip H. 63 Tupper-street, Montreal, Canada.

Year of Election.

1895. ‡GILCHRIST, J. D. F., M.A., Ph.D., B.Sc. Marine Biologist's Office, Department of Agriculture, Cape Town.
1896. *GILCHRIST, PERCY C., F.R.S., M.Inst.C.E. Frognal Bank, Finchley-road, Hampstead, N.W.
1878. ‡Giles, Oliver. Brynteg, The Crescent, Bromsgrove.
1871. *GILL, Sir DAVID, K.C.B., LL.D., D.Sc., F.R.S., F.R.A.S. Royal Observatory, Cape Town.
1902. ‡Gill, James F. 72 Strand-road, Bootle, Liverpool.
1884. ‡Gillman, Henry. 130 Lafayette-avenue, Detroit, Michigan, U.S.A.
1892. *Gilmour, Matthew A. B., F.Z.S. Saffronhall House, Windmill-road, Hamilton, N.B.
1867. ‡Gilroy, Robert. Craigie, by Dundee.
1893. *Gimingham, Edward. 28 Stamford Hill-mansions, Stamford Hill, N.
1904. ‡GINN, S. R., D.L. (Local Sec. 1904.) Brookfield, Trumpington-road, Cambridge.
1900. ‡Ginsburg, Benedict W., M.A., LL.D. 23 Ladbroke-square, W.
1867. ‡GINSBURG, C. D., LL.D. Oakthorpe, Palmer's Green, N.
1884. ‡Girdwood, Dr. G. P. 28 Beaver Hall-terrace, Montreal, Canada.
1886. *Gisborne, Hartley, M.Can.S.C.E. Caragana Lodge, Ladysmith, Vancouver Island, Canada.
1850. *Gladstone, George, F.R.G.S. 34 Denmark-villas, Hove, Brighton.
1883. *Gladstone, Miss. 19 Chepstow-villas, Bayswater, W.
1871. *GLAISHER, J. W. L., M.A., D.Sc., F.R.S., F.R.A.S. (Pres. A, 1890; Council 1878–86.) Trinity College, Cambridge.
1901. ‡Glaister, Professor John, M.D., F.R.S.E. 18 Woodside-place, Glasgow.
1897. ‡Glashan, J. C., LL.D. Ottawa, Canada.
1883. ‡Glasson, L. T. 2 Roper-street, Penrith.
1881. *GLAZEBROOK, R. T., M.A., D.Sc., F.R.S. (Pres. A, 1893; Council 1890–94, 1905–), Director of the National Physical Laboratory. Bushy House, Teddington, Middlesex.
1881. *Gleadow, Frederic. 38 Ladbroke-grove, W.
1859. ‡*Glennie, J. S. Stuart, M.A. Sandycroft, Haslemere, Surrey.*
1874. ‡*Glover, George T. Corby, Hoylake.*
Glover, Thomas. 124 Manchester-road, Southport.
1870. ‡Glynn, Thomas R., M.D. 62 Rodney-street, Liverpool.
1872. ‡GODDARD, RICHARD. (Local Sec. 1873.) 16 Booth-street, Bradford, Yorkshire.
1886. ‡Godlee, Arthur. The Lea, Harborne, Birmingham.
1887. ‡Godlee, Francis. 8 Minshall-street, Manchester.
1878. *Godlee, J. Lister. Wakes Colne Place, Essex.
1880. ‡GODMAN, F. DU CANE, D.C.L., F.R.S., F.L.S., F.G.S. 10 Chandos-street, Cavendish-square, W.
1883. ‡Godson, Dr. Alfred. Cheadle, Cheshire.
1852. ‡Godwin, John. Wood House, Rostrevor, Belfast.
1879. ‡GODWIN-AUSTEN, Lieut.-Colonel H. H., F.R.S., F.R.G.S., F.Z.S. (Pres. E, 1883.) Nore, Godalming.
1876. ‡Goff, Bruce, M.D. Bothwell, Lanarkshire.
1898. ‡Goldney, F. Bennett, F.S.A. Goodnestone Park, Dover.
1886. ‡GOLDSMID, Major-General Sir F. J., K.C.S.I., C.B., F.R.G.S. (Pres. E, 1886.) 29 Phœnix Lodge-mansions, Brook Green, W.
1899. ‡GOMME, G. L., F.S.A. 24 Dorset-square, N.W.
1890. *GONNER, E. C. K., M.A. (Pres. F, 1897), Professor of Political Economy in the University of Liverpool.
1852. ‡Goodbody, Jonathan. Clare, King's County, Ireland.
1878. ‡Goodbody, Jonathan, jun. 50 Dame-street, Dublin.
1834. ‡Goodbody, Robert. Fairy Hill, Blackrock, Co. Dublin.

Year of Election.

1884. *Goodridge, Richard E. W. Lupton, Michigan, U.S.A.
1884. ‡Goodwin, Professor W. L. Queen's University, Kingston, Ontario, Canada.
1905. §GOOLD-ADAMS, Major Sir H. J., K.C.M.G. Government House, Bloemfontein, South Africa.
1885. ‡Gordon, Rev. Cosmo, D.D., F.R.A.S. Chetwynd Rectory, Newport, Salop.
1871. *Gordon, Joseph Gordon, F.C.S. Queen Anne's-mansions, Westminster, S.W.
1893. ‡Gordon, Mrs. M. M., D.Sc. 1 Rubislaw-terrace, Aberdeen.
1884. *Gordon, Robert, M.Inst.C.E., F.R.G.S. Fairview, Dartmouth, Devon.
1885. ‡Gordon, Rev. William. Braemar, N.B.
1865. ‡GORE, GEORGE, LL.D., F.R.S. 20 Easy-row, Birmingham.
1901. §GORST, Right Hon. Sir JOHN E., M.A., K.C., M.P., F.R.S. (Pres. L, 1901). 21 Victoria-square, S.W.
1875. *GOTCH, FRANCIS, M.A., D.Sc., F.R.S. (Council, 1901–), Professor of Physiology in the University of Oxford. The Lawn, Banbury-road, Oxford.
1873. ‡Gott, Charles, M.Inst.C.E. Parkfield-road, Manningham, Bradford, Yorkshire.
1849. ‡Gough, The Hon. Frederick. Perry Hall, Birmingham.
1881. ‡Gough, Rev. Thomas, B.Sc. King Edward's School, Retford.
1894. ‡Gould, G. M., M.D. 119 South 17th-street, Philadelphia, U.S.A.
1888. ‡Gouraud, Colonel. Edison House, Brighton.
1901. ‡GOURLAY, ROBERT. Glasgow.
1901. §Gow, Leonard. Hayston, Kelvinside, Glasgow.
1876. ‡Gow, Robert. Cairndowan, Dowanhill-gardens, Glasgow.
1883. §Gow, Mrs. Cairndowan, Dowanhill-gardens, Glasgow.
1873. §Goyder, Dr. D. Marley House, 88 Great Horton-road, Bradford, Yorkshire.
1886. ‡Grabham, Michael C., M.D. Madeira.
1901. ‡Graham, Robert. 165 Nithsdale-road, Pollokshields, Glasgow.
1902. *Graham, William, M.D. District Lunatic Asylum, Belfast.
1875. ‡GRAHAME, JAMES (Local Sec. 1876). Reform Club, Pall Mall, S.W.
1904. §Gramont, Comte Arnaud de. 179 Rue de l'Université, Paris.
1892. ‡Grange, C. Ernest. 57 Berners-street, Ipswich.
1893. ‡Granger, Professor F. S., M.A., D.Litt. University College, Nottingham.
1896. ‡Grant, Sir James, K.C.M.G. Ottawa, Canada.
1892. ‡*Grant, W. B. 10 Ann-street, Edinburgh.*
1905. §Grant-Dalton, Alan. Arundel, Rondebosch, Cape Colony.
1864. ‡Grantham, Richard F., M.Inst.C.E., F.G.S. 23 Northumberland-avenue, W.C.
1905. §Graumann, Harry. P.O. Box 2115, Johannesburg.
1881. ‡Gray, Alan, LL.B. Minster-yard, York.
1899. ‡Gray, Albert Alexander. 16 Berkeley-terrace, Glasgow.
1890. ‡GRAY, ANDREW, M.A., LL.D., F.R.S., F.R.S.E., Professor of Natural Philosophy in the University of Glasgow.
1899. ‡Gray, Charles. 11 Portland-place, W.
1905. §Gray, C. J. P.O. Box 208, Pietermaritzburg, South Africa.
1864. *Gray, Rev. Canon Charles. West Retford Rectory, Retford.
1876. ‡Gray, Dr. Newton-terrace, Glasgow.
1881. ‡Gray, Edwin, LL.B. Minster-yard, York.
1903. §Gray, Ernest, M.A., M.P. 99 Grosvenor-road, S.W.
1902. ‡*Gray, G., M.D. Newcastle, Co. Down.*
1904. ‡Gray, Rev. H. B., D.D. The College, Bradfield, Berkshire.

Year of Election.

1893. ‡Gray, J. C., General Secretary of the Co-operative Union, Limited Long Millgate, Manchester.
1892. *Gray, James Hunter, M.A., B.Sc. 141 Hopton-road, Streatham, S.W.
1904. ‡Gray, J. Macfarlane. 4 Ladbroke-crescent, W.
1892. §GRAY, JOHN, B.Sc. 9 Park-hill, Clapham Park, S.W.
1887. ‡Gray, Joseph W., F.G.S. St. Elmo, Leckhampton-road, Cheltenham.
1887. ‡Gray, M. H., F.G.S. Lessness Park, Abbey Wood, Kent.
1886. *Gray, Robert Kaye. Lessness Park, Abbey Wood, Kent.
1901. §Gray, R. W. 7 Orme-court, Bayswater, W.
1881. ‡Gray, Thomas, Professor of Engineering in the Rane Technical Institute, Terre Haute, Indiana, U.S.A.
1873. ‡Gray, William, M.R.I.A. Glenburn Park, Belfast.
*GRAY, Colonel WILLIAM. Farley Hall, near Reading.
1883. ‡Gray, William Lewis. Westmoor Hall, Brimsdown, Middlesex.
1883. ‡Gray, Mrs. W. L. Westmoor Hall, Brimsdown, Middlesex.
1886. ‡Greaney, Rev. William. Bishop's House, Bath-street, Birmingham.
1866. §Greaves, Charles Augustus, M.B., LL.B. 84 Friar-gate, Derby.
1893. *Greaves, Mrs. Elizabeth. Station-street, Nottingham.
1869. ‡Greaves, William. Station-street, Nottingham.
1872. ‡Greaves, William. 33 Marlborough-place, N.W.
1872. *Grece, Clair J., LL.D. 146 Station-road, Redhill, Surrey.
1905. §Green, A. F. Sea Point, Cape Colony.
1904. *Green, A. G. 2 Dartmouth-road, Brondesbury, N.W.
1904. §Green, F. W. Thornfield, Tunbridge Wells. After April 30, St. John's College, Cambridge.
1888. §GREEN, J. REYNOLDS, M.A., D.Sc., F.R.S., F.L.S. (Pres. K, 1902), Professor of Botany to the Pharmaceutical Society of Great Britain. 61A St. Andrew's-street, Cambridge.
1903. §Green, W. J. 49 Kingston-crescent, Portsmouth.
1882. ‡GREENHILL, A. G., M.A., F.R.S., Professor of Mathematics in the Royal Artillery College, Woolwich. 1 Staple Inn, W.C.
1905. §Greenhill, Henry H. P.O Box 172, Bloemfontein, South Africa.
1905. §Greenhill, William. 6A George-street, Edinburgh.
1881. ‡Greenhough, Edward. Matlock Bath, Derbyshire.
1884. ‡Greenish, Thomas, F.C.S. 20 New-street, Dorset-square, N.W.
1898. *GREENLY, EDWARD. Achnashean, near Bangor, North Wales.
1884. ‡Greenshields, E. B. Montreal, Canada.
1884. ‡Greenshields, Samuel. Montreal, Canada.
1887. ‡Greenwell, G. C. Beechfield, Poynton, Cheshire.
1863. ‡Greenwell, G. E. Poynton, Cheshire.
1890. ‡Greenwood, Arthur. Cavendish-road, Leeds.
1875. ‡Greenwood, F., M.B. Brampton, Chesterfield.
1887. ‡Greenwood, W. H., M.Inst.C.E. Adderley Park Rolling Mills, Birmingham.
1861. *GREG, ROBERT PHILIPS, F.G.S., F.R.A.S. Coles Park, Buntingford, Herts.
1894. *GREGORY, Professor J. WALTER, D.Sc., F.R.S., F.G.S. The University, Glasgow.
1896. *Gregory, Professor R. A., F.R.A.S. Dell Quay House, near Chichester.
1904. §Gregory, R. P. St. John's College, Cambridge.
1883. ‡*Gregson, G. E. Ribble View, Preston.*
1881. ‡Gregson, William, F.G.S. Baldersby, S.O., Yorkshire.
1859. ‡GRIERSON, THOMAS BOYLE, M.D. Thornhill, Dumfriesshire.
1878. ‡*Griffin, Robert, M.A., LL.D. Trinity College, Dublin.*

Year of Election.

1836. Griffin, S. F. Albion Tin Works, York-road, N.
1894. *Griffith, C. L. T., Assoc.M.Inst.C.E. Flambards, Harrow.
1884. ‡GRIFFITHS, E. H., M.A., D.Sc., F.R.S., Principal of University College, Cardiff.
1884. ‡Griffiths, Mrs. University College, Cardiff.
1891. ‡Griffiths, P. Rhys, B.Sc., M.B. 71 Newport-road, Cardiff.
1903. ‡Griffiths, Thomas, J.P. 101 Manchester-road, Southport.
1847. ‡Griffiths, Thomas. The Elms, Harborne-road, Edgbaston, Birmingham.
1888. *Grimshaw, James Walter, M.Inst C.E. 5 Elchester-gardens, Bayswater, W.
1884. ‡Grinnell, Frederick. Providence, Rhode Island, U.S.A.
1894. ‡GROOM, Professor P., M.A., F.L.S. Hollywood, Egham, Surrey.
1894. ‡Groom, T. T., D.Sc. University College, Reading.
1896. ‡Grossmann, Dr. Karl. 70 Rodney-street, Liverpool.
1904. ‡Grosvenor, G. H. New College, Oxford.
1891. ‡Grover, Henry Llewellin. Clydach Court, Pontypridd.
1869. ‡GRUBB, Sir HOWARD, F.R.S., F.R.A.S. Rockdale, Orwell-road, Rathgar, Dublin.
1897. ‡Grünbaum, A. S., M.A., M.D. 45 Ladbroke-grove, W.
1897. ‡Grünbaum, O. F. F., B.A., D.Sc. 45 Ladbroke-grove, W.
1886. ‡*Grundy, John. 17 Private-road, Mapperley, Nottingham.*
1891. ‡Grylls, W. London and Provincial Bank, Cardiff.
1887. ‡GUILLEMARD, F. H. H., M.A., M.D. The Mill House, Trumpington, Cambridge.
Guinness, Henry. 17 College-green, Dublin.
1842. Guinness, Richard Seymour. 17 College-green, Dublin.
1905. *Gunn, Donald. Royal Societies Club, St. James's-street, S.W.
1891. ‡Gunn, Sir John. Llandaff House, Llandaff.
1866. ‡GÜNTHER, ALBERT C. L. G., M.A., M.D., Ph.D., F.R.S., F.L.S., F.Z.S. (Pres. D, 1880.) 22 Lichfield-road, Kew, Surrey.
1894. ‡Günther, R. T. Magdalen College, Oxford.
1880. §Guppy, John J. Ivy-place, High-street, Swansea.
1904. §Gurney, Eustace. Sprowston Hall, Norwich.
1902. *Gurney, Robert. Ingham Old Hall, Stalham, Norfolk.
1883. ‡Guthrie, Malcolm. Prince's-road, Liverpool.
1896. ‡*Guthrie, Tom, B.Sc. Yorkshire College, Leeds.*
1904. §Guttmann, Leo F., Ph.D. 18 Aberdare-gardens, N.W.
1876. ‡GWYTHER, R. F., M.A. Owens College and 33 Heaton-road, Withington, Manchester.

1905. §Hacker, Rev. W. J. Pietermaritzburg, South Africa.
1884. ‡Hadden, Captain C. F., R.A. Woolwich.
1881. *HADDON, ALFRED CORT, M.A., D.Sc., F.R.S., F.Z.S. (Pres. H, 1902, 1905; Council, 1902– .) Inisfail, Hills-road, Cambridge.
1905. §Haddon, Miss. Isinfail, Hills-road, Cambridge.
1888. *Hadfield, R. A., M.Inst.C.E. Parkhead House, Sheffield.
1905. §Hahn, Professor P. H., M.A., Ph.D. York House, Gardens, Cape Town.
1870. ‡Haigh, George. 27 Highfield South, Rockferry, Cheshire.
1899. ‡Hall, A. D., M.A., Director of the Rothamsted Experimental Station, Harpenden, Herts.
1903. ‡HALL, E. MARSHALL, K.C., M.P. 75 Cambridge-terrace, W.
1879. *Hall, Ebenezer. Abbeydale Park, near Sheffield.
1883. *Hall, Miss Emily. 17 Belmont Street, Southport.

Year of Election.

1881. ‡Hall, Frederick Thomas, F.R.A.S. 15 Gray's Inn-square, W.C.
1854. *HALL, HUGH FERGIE, F.G.S. Cissbury Court, West Worthing, Sussex.
1899. ‡Hall, John, M.D. National Bank of Scotland, 37 Nicholas-lane, E.C.
1885. §Hall, Samuel, F.I.C., F.C.S. 19 Aberdeen-park, Highbury, N.
1900. ‡Hall, T. Farmer, F.R G.S. 39 Gloucester-square, Hyde Park, W.
1896. ‡Hall, Thomas B. Larch Wood, Rockferry, Cheshire.
1884. ‡Hall, Thomas Proctor. School of Practical Science, Toronto, Canada.
1896. ‡Hall-Dare, Mrs. Caroline. 13 Great Cumberland-place, W.
1891. *Hallett, George. Oak Cottage, West Malvern.
1891. ‡Hallett, J. H., M.Inst.C.E. Maindy Lodge, Cardiff.
1873. *HALLETT, T. G. P., M.A. Claverton Lodge, Bath.
1888. §HALLIBURTON, W. D., M.D., F.R.S. (Pres. I, 1902; Council 1897–1903), Professor of Physiology in King's College, London. Church Cottage, 17 Marylebone-road, N.W.
1905. §Halliburton, Mrs. Church Cottage, 17 Marylebone-road, N.W.
1904. *Hallidie, A. H. S. Avondale, Chesterfield-road, Eastbourne.
1858. *Hambly, Charles Hambly Burbridge, F.G.S. Fairley, Weston, Bath.
1904. *Hamel de Manin, Anna Countess de. 35 Circus-road, N.W.
1883. *Hamel, Egbert D. de. Middleton Hall, Tamworth.
1885. ‡Hamilton, David James. 41 Queen's-road, Aberdeen.
1902. ‡HAMILTON, Rev. T., D.D. Queen's College, Belfast.
1905. §Hammersley-Heenan, R. H., M.Inst.C.E. Harbour Board Offices, Cape Town.
1905. §Hammond, Miss Edith. High Dene, Woldingham, Surrey.
1881. *Hammond, Robert, M.Inst.C.E. 64 Victoria-street, Westminster, S.W.
1899. *Hanbury, Daniel. Lenqua da Cà, Alassio, Italy.
1892. ‡Hanbury, Thomas, F.L.S. La Mortola, Ventimiglia, Italy.
1878. ‡Hance, Edward M., LL.B. 17 Percy-street, Liverpool.
1875. ‡Hancock, C. F., M.A. 125 Queen's-gate, S.W.
1897. ‡*HANCOCK, HARRIS. University of Chicago, U.S.A.*
1905. *Hancock, Strangman, J. P. P.O. Box 1, Cleveland, Transvaal.
1861. ‡Hancock, Walter. 10 Upper Chadwell-street, Pentonville, E.C.
1890. ‡Hankin, Ernest Hanbury. St. John's College, Cambridge.
1884. ‡Hannaford, E. P., M.Inst.C.E. 2573 St. Catherine-street, Montreal.
1894. §Hannah, Robert, F.G.S. 82 Addison-road, W.
1886. §Hansford, Charles, J.P. Englefield House, Dorchester.
1904. §Hanson, E. K. University College, Reading.
1902. ‡Harbison, Adam, B.A. 5 Ravenhill-terrace, Ravenhill-road, Belfast.
1859. *HARCOURT, A. G. VERNON, M.A., D.C.L., LL.D., F.R.S., V.P.C.S. (GEN. SEC. 1883–97; Pres. B, 1875; Council 1881–83). St. Clare, Ryde, Isle of Wight.
1890. *HARCOURT, L. F. VERNON, M.A., M.Inst.C.E. (Pres. G, 1895; Council 1895–1901). 6 Queen Anne's-gate, S.W.
1897. §Harcourt, Hon. R., LL.D., K.C., Minister of Education for the Province of Ontario. Toronto, Canada.
1886. *Hardcastle, Colonel Basil W., F.S.S. 12 Gainsborough-gardens, Hampstead, N.W.
1902. *HARDCASTLE, Miss FRANCES. 25 Boundary-road, N.W.
1903. *Hardcastle, J. Alfred. The Dial House, Crowthorne, Berkshire.
1892. *HARDEN, ARTHUR, Ph.D., M.Sc. Lister Institute of Preventive Medicine, Chelsea-gardens, Grosvenor-road, S.W.

Year of Election.

1905. §Hardie, Miss Mabel, M.B. High Lane, viâ Stockport.
1877. ‡Harding, Stephen. Bower Ashton, Clifton, Bristol.
1869. ‡Harding, William D. Islington Lodge, King's Lynn, Norfolk.
1894. ‡Hardman, S. C. 120 Lord-street, Southport.
1894. ‡Hare, A. T., M.A. Neston Lodge, East Twickenham, Middlesex.
1894. ‡Hare, Mrs. Neston Lodge, East Twickenham, Middlesex.
1898. ‡Harford, W. H. Oldown House, Almondsbury.
1858. ‡Hargrave, James. Burley, near Leeds.
1883. ‡Hargreaves, Miss H. M. 69 Alexandra-road, Southport.
1883. ‡Hargreaves, Thomas. 69 Alexandra-road, Southport.
1890. ‡Hargrove, Rev. Charles. 10 De Grey-terrace, Leeds.
1881. ‡Hargrove, William Wallace. St. Mary's, Bootham, York.
1890. *HARKER, ALFRED, M.A., F.R.S., F.G.S. St. John's College, Cambridge.
1896. ‡Harker, Dr. John Allen. National Physical Laboratory, Bushy House, Teddington.
1887. ‡Harker, T. H. Brook House, Fallowfield, Manchester.
1875. *Harland, Rev. Albert Augustus, M.A., F.G.S., F.L.S., F.S.A. The Vicarage, Harefield, Middlesex.
1905. §Harland, H. C. P.O. Box 1024, Johannesburg.
1877. *Harland, Henry Seaton. 8 Arundel-terrace, Brighton.
1883. *Harley, Miss Clara. Rosslyn, Westbourne-road, Forest Hill, S.E.
1883. **Harley, Harold.* *14 Chapel-street, Bedford-row, W.C.*
1862. *HARLEY, Rev. ROBERT, M.A., F.R.S., F.R.A.S. Rosslyn, Westbourne-road, Forest Hill, S.E.
1899. ‡Harman, Dr. N. Bishop. St. John's College, Cambridge.
1868. *HARMER, F. W., F.G.S. Oakland House, Cringleford, Norwich.
1881. *HARMER, SIDNEY F., M.A., D.Sc., F.R.S. King's College, Cambridge.
1872. ‡Harpley, Rev. William, M.A. Clayhanger Rectory, Tiverton.
1884. ‡Harrington, B. J., B.A., Ph.D., F.G.S., Professor of Chemistry and Mineralogy in McGill University, Montreal. University-street, Montreal, Canada.
1888. ‡Harris, C. T. 4 Kilburn Priory, N.W.
1842. *Harris, G. W., M.Inst.C.E. Millicent, South Australia.
1889. §HARRIS, H. GRAHAM, M.Inst.C.E. 5 Great George-street, Westminster, S.W.
1903. ‡Harris, Robert, M.B. 18 Duke-street, Southport.
1898. ‡Harrison, A. J., M.D. Failand Lodge, Guthrie-road, Clifton, Bristol.
1888. ‡Harrison, Charles. 20 Lennox-gardens, S.W.
1860. ‡Harrison, Rev. Francis, M.A. North Wraxall, Chippenham.
1904. §Harrison, Frank L. 83 Clarkehouse-road, Sheffield.
1904. §Harrison, H. Spencer. The Horniman Museum, Forest Hill, S.E.
1889. ‡Harrison, J. C. Oxford House, Castle-road, Scarborough.
1892. ‡HARRISON, JOHN (Local Sec. 1892). Rockville, Napier-road, Edinburgh.
1870. ‡HARRISON, REGINALD, F.R.C.S. (Local Sec. 1870). 6 Lower Berkeley-street, Portman-square, W.
1853. ‡Harrison, Robert. 36 George-street, Hull.
1892. ‡Harrison, Rev. S. N. Ramsey, Isle of Man.
1895. ‡Harrison, Thomas. 48 High-street, Ipswich.
1901. *Harrison, W. E. 15 Lansdowne-road, Handsworth, Staffordshire.
1886. ‡Harrison, W. Jerome, F.G.S. Board School, Icknield-street, Birmingham.
1885. ‡HART, Colonel C. J. (Local Sec. 1886.) Highfield Gate, Edgbaston, Birmingham.
1876. *Hart, Thomas. Brooklands, Blackburn.

Year of Election.

1903. *Hart, Thomas Clifford. Brooklands, Blackburn.
1875. ‡Hart, W. E. Kilderry, near Londonderry.
1893. *HARTLAND, E. SIDNEY, F.S.A. Highgarth, Gloucester.
1905. §Hartland, Miss. Highgarth, Gloucester.
1897. ‡Hartley, E. G. S. Wheaton Astley Hall, Stafford.
1896. ‡Hartley, W. P., J.P. Aintree, Liverpool.
1871 *HARTLEY, WALTER NOEL, D.Sc., F.R.S., F.R.S.E., F.C.S. (Pres. B, 1903), Professor of Chemistry in the Royal College of Science, Dublin. 36 Waterloo-road, Dublin.
1886. *HARTOG, Professor M. M., D.Sc. Queen's College, Cork.
1887. ‡HARTOG, P. J., B.Sc. University of London, South Kensington, S.W.
1897. ‡Harvey, Arthur. Rosedale, Toronto, Canada.
1898. ‡Harvey, Eddie. 10 The Paragon, Clifton, Bristol.
1905. §Harvey-Hogan, J. P.O. Box 1277, Johannesburg.
1885. §Harvie-Brown, J. A. Dunipace, Larbert, N.B.
1862. *Harwood, John. Woodside Mills, Bolton-le-Moors.
1884. ‡Haslam, Rev. George, M.A. Trinity College, Toronto, Canada.
1893. §Haslam, Lewis. 44 Evelyn-gardens, S.W.
1903. *Hastie, Miss J. A. Care of Messrs. Street & Co., 30 Cornhill, E.C.
1903. §Hastie, William. 20 Elswick-row, Newcastle-on-Tyne.
1904. ‡Hastings, G. 15 Oak-lane, Bradford, Yorkshire.
1875. *HASTINGS, G. W. (Pres. F, 1880.) Chapel House, Chipping Norton.
1903. §Hastings, W. G. W. Chapel House, Chipping Norton.
1889. ‡Hatch, F. H., Ph.D., F.G.S. P.O. Box 1030, Johannesburg.
1903. ‡Hathaway, Herbert G. 45 High-street, Bridgnorth, Salop.
1893. ‡Hatton, John L. S. People's Palace, Mile End-road, E.
1904. *Haughton, W. T. H. The Highlands, Great Barford, St. Neots.
1904. ‡Havilland, Hugh de. Eton College, Windsor.
1887. *Hawkins, William. Earlston House, Broughton Park, Manchester.
1872. *Hawkshaw, Henry Paul. 58 Jermyn-street, St. James's, S.W.
1864. *HAWKSHAW, JOHN CLARKE, M.A., M.Inst.C.E., F.G.S. (Council 1881–87.) 22 Down-street, W., and 33 Great George-street, S.W.
1897. §HAWKSLEY, CHARLES, M Inst.C.E. (Pres. G, 1903; Council, 1902– .) 30 Great George-street, S.W.
1889. ‡Haworth, George C. Ordsal, Salford.
1887. *Haworth, Jesse. Woodside, Bowdon, Cheshire.
1890. ‡Hawtin, J. N. Sturdie House, Roundhay-road, Leeds.
1861. *HAY, Admiral the Right Hon. Sir JOHN C. D., Bart., G.C.B., D.C.L., F.R.S. 108 St. George's-square, S.W.
1885. *HAYCRAFT, JOHN BERRY, M.D., B.Sc., F.R.S.E., Professor of Physiology in University College, Cardiff.
1891. ‡Hayde, Rev. J. St. Peter's, Cardiff.
1900. §Hayden, H. H., B.A., F.G.S. Geological Survey, Calcutta, India.
1903. *Haydock, Arthur. 197 Preston New-road, Blackburn.
1894. ‡Hayes, Edward Harold. 5 Rawlinson-road, Oxford.
1896. ‡Hayes, Rev. F. C. The Rectory, Raheny, Dublin.
1896. ‡Hayes, William. Fernyhurst, Rathgar, Dublin.
1873. *Hayes, Rev. William A., M.A. Dromore, Co. Down, Ireland.
1898. ‡Hayman, C. A. Kingston Villa, Richmond Hill, Clifton, Bristol.
1903. §Hayward, Joseph William, M.Sc. 29 Deodar-road, Putney, S.W.
1896. *Haywood, Lieut.-Colonel A. G. Rearsby, Merrilocks-road, Blundellsands.
1879. *Hazelhurst, George S. The Grange, Rockferry.
1883. ‡Headley, Frederick Halcombe. Manor House, Petersham, S.W.
1883. ‡Headley, Mrs. Marian. Manor House, Petersham, S.W.
1883. ‡Heape, Charles. Tovrak, Oxton, Cheshire.

Year of Election.

1883. ‡Heape, Joseph R. Glebe House, Rochdale.
1882. *Heape, Walter, M.A. Heyroun, Chaucer-road, Cambridge.
1877. ‡Hearder, Henry Pollington. Westwell-street, Plymouth.
1877. ‡Hearder, William Keep. 195 Union-street, Plymouth.
1898. *Heath, Rev. Arthur J., B.A., F.G.S. 71 St. Michael's-hill, Redlands, Bristol.
1902. ‡Heath, J. W. Royal Institution, Albemarle-street, W.
1898. ‡HEATH, R. S., M.A., D.Sc. The University, Birmingham.
1884. ‡Heath, Thomas, B.A. Royal Observatory, Edinburgh.
1902. §Heathorn, Captain T. B., R.A. 10 Wilton-place, Knightsbridge, S.W.
1883. ‡Heaton, Charles. Marlborough House, Hesketh Park, Southport.
1892. *HEATON, WILLIAM H., M.A. (Local Sec. 1893), Professor of Physics in University College, Nottingham.
1889. *Heaviside, Arthur West. 12 Tring-avenue, Ealing, W.
1888. *Heawood, Edward, M.A. Briarfield, Church-hill, Merstham, Surrey.
1888. *Heawood, Percy J., Lecturer in Mathematics in Durham University. 41 Old Elvet, Durham.
1855. ‡HECTOR, Sir JAMES, K.C.M.G., M.D., F.R.S., F.G.S., Director of the Geological Survey of New Zealand. Wellington, New Zealand.
1887. *HEDGES, KILLINGWORTH, M.Inst.C.E. 10 Cranley-place, South Kensington, S.W.
1881. *HELE-SHAW, H. S., LL.D., F.R.S., M.Inst.C.E. 29 Clarence Gate-gardens, N.W.
1901. *Heller, W. M., B.Sc. 40 Upper Sackville-street, Dublin.
1905. §Hellman, Hugo. Rand Club, Johannesburg.
1887. §Hembry, Frederick William, F.R.M.S. Langford, Sidcup, Kent.
1899. ‡Hemsalech, G. A., D.Sc. The Owens College, Manchester.
1873. *Henderson, A. L. Westmoor Hall, Brimsdown, Middlesex.
1883. ‡Henderson, Mrs. A. L. Westmoor Hall, Brimsdown, Middlesex.
1905. *Henderson, Andrew. 17 Belhaven-terrace, Glasgow.
1901. ‡Henderson, Rev. Andrew, LL.D. Castle Head, Paisley.
1905. *Henderson, Miss Catharine. 17 Belhaven-terrace, Glasgow.
1891. *HENDERSON, G. G., D.Sc., M.A., F.I.C., Professor of Chemistry in the Glasgow and West of Scotland Technical College, Glasgow.
1905. §Henderson, Mrs. Technical College, Glasgow.
1892. ‡*Henderson, John. 3 St. Catherine-place, Grange, Edinburgh.*
1880. *Henderson, Rear-Admiral W. H., R.N. Royal Dockyard, Devonport.
1896. ‡*Henderson, W. Saville, B.Sc. Beech Hill, Fairfield, Liverpool.*
1904. *Hendrick, James. Marischal College, Aberdeen.
1873. *HENRICI, OLAUS M. F. E., Ph.D., F.R.S. (Pres. A, 1883; Council, 1883-89), Professor of Mechanics and Mathematics in the City and Guilds of London Institute, Central Institution, Exhibition-road, S.W. 34 Clarendon-road, Notting Hill, W.
1892. ‡HEPBURN, DAVID, M.D., F.R.S.E., Professor of Anatomy in University College, Cardiff.
1855. *Hepburn, J. Gotch, LL.B., F.C.S. Oakfield Cottage, Dartford Heath, Kent.
1890. ‡Hepper, J. 43 Cardigan-road, Headingley, Leeds.
1890. ‡Hepworth, Joseph. 25 Wellington-street, Leeds.
1904. §Hepworth, Commander M. W. C., R.N.R., C.B. Meteorological Office, Victoria-street, S.W.
1892. *HERBERTSON, ANDREW J., Ph.D., F.R.S.E., F.R.G.S. 4 Broad-street, Oxford.
1902. ‡Herdman, G. W., B.Sc., Assoc.M.Inst.C.E. Irrigation and Water Supply Department, Pretoria.

Year of Election.

1887. *HERDMAN, WILLIAM A., D.Sc., F.R.S., F.R.S.E., Pres.L.S. (GENERAL SECRETARY, 1903– ; Pres. D, 1895; Council, 1894–1900; Local Sec. 1896), Professor of Natural History in the University of Liverpool. Croxteth Lodge, Sefton Park, Liverpool.
1893. *Herdman, Mrs. Croxteth Lodge, Sefton Park, Liverpool.
1875. ‡HEREFORD, The Right Rev. JOHN PERCIVAL, D.D., LL.D., Lord Bishop of. (Pres. L, 1904.) The Palace, Hereford.
1871. *HERSCHEL, ALEXANDER S., M.A., D.C.L., F.R.S., F.R.A.S., Honorary Professor of Physics and Experimental Philosophy in the University of Durham. Observatory House, Slough, Bucks.
1874. §HERSCHEL, Colonel JOHN, R.E., F.R.S., F.R.A.S. Observatory House, Slough, Bucks.
1900. *Herschel, J. C. W. 92 Woodstock-road, Oxford.
1900. ‡Herschel, Sir W. J., Bart. Littlemore, Oxford.
1905. §Hervey, Miss Mary F. S. 22 Morpeth-mansions, S.W.
1903. *HESKETH, CHARLES H. B., M.A. The Rookery, North Meols, Southport.
1895. §Hesketh, James. Scarisbrick Avenue-buildings, 107 Lord-street, Southport.
1905. §Hewat, M. L., M.D. Mowbray, South Africa.
1894. ‡HEWETSON, G. H. (Local Sec. 1896.) 39 Henley-road, Ipswich.
1894. ‡Hewins, W. A. S., M.A., F.S.S., Professor of Political Economy in King's College, Strand, W.C.
1896. §Hewitt, David Basil. Oakleigh, Northwich, Cheshire.
1903. ‡Hewitt, E. G. W. 87 Princess-road, Moss Side, Manchester.
1903. ‡Hewitt, John Theodore, M.A., D.Sc., Ph.D. 8 Montpellier-road, Twickenham.
1893. ‡Hewitt, Thomas P. Eccleston Park, Prescot, Lancashire.
1883. ‡Hewson, Thomas. Junior Constitutional Club, Piccadilly, W.
1882. *HEYCOCK, CHARLES T., M.A., F.R.S. King's College, Cambridge.
1883. ‡Heyes, Rev. John Frederick, M.A., F.R.G.S. 27 Arkwright-street, Bolton.
1866. *Heymann, Albert. West Bridgford, Nottinghamshire.
1897. ‡Heys, Thomas. 130 King-street West, Toronto, Canada.
1901. *Heys, Z. John. Stonehouse, Barrhead, N.B.
1879. ‡Heywood, Sir A. Percival, Bart. Duffield Bank, Derby.
1886. ‡HEYWOOD, HENRY, J.P. Witla Court, near Cardiff.
1887. ‡*Heywood, Robert. Mayfield, Victoria Park, Manchester.*
1888. ‡Hichens, James Harvey, M.A. The School House, Wolverhampton.
1898. ‡Hicks, Henry B. 44 Pembroke-road, Clifton, Bristol.
1877. §HICKS, Professor W. M., M.A., D.Sc., F.R.S. (Pres. A, 1895), Professor of Physics in the University of Sheffield. Dunheved, Endcliffe-crescent, Sheffield.
1886. ‡Hicks, Mrs. W. M. Dunheved, Endcliffe-crescent, Sheffield.
1884. ‡Hickson, Joseph. 272 Mountain-street, Montreal, Canada.
1887. *HICKSON, SYDNEY J., M.A., D.Sc., F.R.S. (Pres. D, 1903), Professor of Zoology in Victoria University, Manchester.
1864. *HIERN, W. P., M.A., F.R.S. The Castle, Barnstaple.
1891. ‡HIGGS, HENRY, LL.B., F.S.S. (Pres. F, 1899; Council 1904– .) H.M. Treasury, Whitehall, S.W.
1885. *HILL, ALEXANDER, M.A., M.D. Downing College, Cambridge.
1903. *Hill, Arthur W. King's College, Cambridge.
1881. *HILL, Rev. EDWIN, M.A. The Rectory, Cockfield, Bury St. Edmunds.
1887. ‡Hill, G. H., M.Inst.C.E., F.G.S. Albert-chambers, Albert-square, Manchester.
1884. ‡Hill, Rev. James Edgar, M.A., B.D. 2488 St. Catherine-street, Montreal, Canada.

Year of Election.

1886. ‡HILL, M. J. M., M.A., D.Sc., F.R.S., Professor of Pure Mathematics in University College, W.C.
1885. *Hill, Sidney. Langford House, Langford, Bristol.
1898. *Hill, Thomas Sidney. 80 Harvard-court, West End-lane, N.W.
1888. ‡Hill, William. Hitchin, Herts.
1876. ‡Hill, William H. Barlanark, Shettleston, N.B.
1885. *HILLHOUSE, WILLIAM, M.A., F.L.S., Professor of Botany in the University of Birmingham. 16 Duchess-road, Edgbaston, Birmingham.
1886. §Hillier, Rev. E. J. Cardington Vicarage, near Bedford.
1887. ‡Hilton, Edwin. Oak Bank, Fallowfield, Manchester.
1903. *Hilton, Harold. Bryn Teg-terrace, Bangor, North Wales.
1903. §HIND, Dr. WHEELTON, F.G.S. Roxeth House, Stoke-on-Trent.
1870. ‡HINDE, G. J., Ph.D., F.R.S., F.G.S. Ivythorn, Avondale-road, South Croydon, Surrey.
1883. *Hindle, James Henry. 8 Cobham-street, Accrington.
1888. *Hindmarsh, William Thomas, F.L.S. Alnbank, Alnwick.
1898. §Hinds, Henry. 57 Queen-street, Ramsgate.
1881. ‡Hingston, J. T. Clifton, York.
1884. ‡HINGSTON, Sir WILLIAM HALES, M.D., D.C.L. 37 Union-avenue, Montreal, Canada.
1900. §Hinks, Arthur R., M.A. The Observatory, Cambridge.
1903. *Hinmers, Edward. Glentwood, South Down-drive, Hale, Cheshire.
1884. ‡Hirschfilder, C. A. Toronto, Canada.
1899. §Hobday, Henry. Hazelwood, Crabble Hill, Dover.
1905. §Hobhouse, E., M.D. 12 Second-avenue, Brighton.
1905. §Hobhouse, Mrs. 12 Second-avenue, Brighton.
1887. *Hobson, Bernard, M.Sc., F.G.S. Thornton, Didsbury, near Manchester.
1883. ‡Hobson, Mrs. Carey. 5 Beaumont-crescent, West Kensington, W.
1883. ‡*Hobson, Rev. E. W. 55 Albert-road, Southport.*
1904. §Hobson, Ernest William, Sc.D., F.R.S. The Gables, Mount Pleasant, Cambridge.
1877. ‡Hodge, Rev. John Mackey, M.A. 38 Tavistock-place, Plymouth.
1876. ‡Hodges, Frederick W. Queen's College, Belfast.
1863. *HODGKIN, THOMAS, B.A., D.C.L. Benwell Dene, Newcastle-upon-Tyne.
1887. *Hodgkinson, Alexander, M.B., B.Sc., Lecturer on Laryngology at Owens College, Manchester. 18 St. John-street, Manchester.
1896. ‡Hodgkinson, Arnold. 22 Park-road, Southport.
1880. §Hodgkinson, W. R. Eaton, Ph.D., F.R.S.E., F.G.S., Professor of Chemistry and Physics in the Royal Artillery College, Woolwich. 18 Glenluce-road, Blackheath, S.E.
1884. ‡Hodgson, Jonathan. Montreal, Canada.
1905. §Hodgson, Archdeacon R. The Rectory, Wolverhampton.
1863. ‡Hodgson R. W. 7 Sandhill, Newcastle-upon-Tyne.
1898. ‡Hodgson, T. V. Municipal Museum and Art Gallery, Plymouth.
1896. ‡Hodgson, Dr. William, J.P. Helensville, Crewe.
1904. §Hodson, F. Bedale's School, Petersfield, Hampshire.
1904. ‡Hogarth, D. G., M.A. Chapel Meadow, Forest Row, Sussex.
1894. ‡Hogg, A. F., M.A. 13 Victoria-road, Darlington.
1894. ‡Holah, Ernest. 5 Crown-court, Cheapside, E.C.
1883. ‡Holden, James. 12 Park-avenue, Southport.
1883. ‡Holden, John J. 73 Albert-road, Southport.
1884. ‡Holden, Mrs. Mary E. Dunham Ladies' College, Quebec, Canada.
1887. *Holder, Henry William, M.A. Sheet, near Petersfield.
1896. ‡Holder, Thomas. 2 Tithebarn-street, Liverpool.

Year of Election.

1900. §HOLDICH, Colonel Sir THOMAS H., R.E., K.C.B., K.C.I.E., F.R.G.S. (Pres. E, 1902.) 41 Courtfield-road, S.W.
1887. *Holdsworth, C. J. Sunnyside, Wilmslow, Cheshire.
1891. ‡Holgate, Benjamin, F.G.S. The Briers, North Park-avenue, Roundhay, Leeds.
1904. §Holland, Charles E. 9 Downing-place, Cambridge.
1903. §Holland, J. L., B.A. 72 Kingsley Park-terrace, Northampton.
1896. ‡Holland, Mrs. Lowfields House, Hooton, Cheshire.
1898. ‡Holland, Thomas H., F.R.S., F.G.S. Geological Survey Office, Calcutta.
1889. ‡Holländer, Bernard, M.D. King's College, Strand, W.C.
1886. ‡Holliday, J. R. 101 Harborne-road, Birmingham.
1883. ‡Hollingsworth, Dr. T. S. Elford Lodge, Spring Grove, Isleworth.
1905. §Hollway, H. C. Schunke. Plaisir de Merle, P.O. Simondium, viâ Paarl, South Africa.
1883. *Holmes, Mrs. Basil. 5 Freeland-road, Ealing, Middlesex, W.
1866. *Holmes, Charles. 24 Aberdare-gardens, West Hampstead, N.W.
1882. *HOLMES, THOMAS VINCENT, F.G.S. 28 Croom's-hill, Greenwich, S.E.
1903. *Holt, Alfred, jun., J.P. Crofton, Aigburth, Liverpool.
1896. ‡Holt, William Henry. 11 Ashville-road, Birkenhead.
1897. ‡Holterman, R. F. Brantford, Ontario, Canada.
1875. *Hood, John. Chesterton, Cirencester.
1904. §Hooke, Rev. D. Burford. Bonchurch Lodge, Barnet.
1847. ‡HOOKER, Sir JOSEPH DALTON, G.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S., F.L.S., F.G.S., F.R.G.S. (PRESIDENT, 1868; Pres. E, 1881; Council 1866–67.) The Camp, Sunningdale, Berkshire.
1892. ‡HOOKER, REGINALD H., M.A. 3 Gray's Inn-place, W.C.
1865. *Hooper, John P. Deepdene, Streatham Common, S.W.
1877. *Hooper, Rev. Samuel F., M.A. Lydlinch Rectory, Sturminster Newton, Dorset.
1904. ‡Hopewell-Smith, A., M.R.C.S. 37 Park-street, Grosvenor-square, S.W.
1905. *Hopkins, Charles Hadley. Junior Constitutional Club, 101 Piccadilly, W.
1901. *Hopkinson, Bertram, M.A. Holmwood, Wimbledon.
1884. *HOPKINSON, CHARLES (Local Sec. 1887). The Limes, Didsbury, near Manchester.
1882. *Hopkinson, Edward, M.A., D.Sc. Ferns, Alderley Edge, Cheshire.
1871. *HOPKINSON, JOHN, Assoc.M.Inst.C.E., F.L.S., F.G.S., F.R.Met.Soc. 84 New Bond-street, W.; and Weetwood, Watford.
1905. §Hopkinson, Mrs. John. Holmwood, Wimbledon Common, S.W.
1858. ‡Hopkinson, Joseph, jun. Britannia Works, Huddersfield.
1891. ‡Horder, T. Garrett. 10 Windsor-place, Cardiff.
1898. *Hornby, R., M.A. Haileybury College, Hertford.
1885. ‡HORNE, JOHN, LL.D., F.R.S., F.R.S.E., F.G.S. (Pres. C, 1901.) Geological Survey Office, Sheriff Court-buildings, Edinburgh.
1903. §Horne, William, F.G.S. Leyburn, Yorkshire.
1902. ‡Horner, John. Chelsea, Antrim-road, Belfast.
1875. *Horniman, F. J., M.P., F.R.G.S., F.L.S. Falmouth House, 20 Hyde Park-terrace, W.
1905. *Horsburgh, E. M., M.A., B.Sc., Lecturer in Technical Mathematics in the University of Edinburgh.
1884. *Horsfall, Richard. Stoodley House, Halifax.
1887. ‡Horsfall, T. C. Swanscoe Park, near Macclesfield.
1893. *HORSLEY, Sir VICTOR A. H., B.Sc., F.R.S., F.R.C.S. (Council, 1893–98.) 25 Cavendish-square, W.

Year of Election.

1884. *Hotblack, G. S. Brundall, Norwich.
1899. ‡Hotblack, J. T., F.G.S. 45 Newmarket-road, Norwich.
1859. ‡Hough, Joseph, M.A., F.R.A.S. Codsall Wood, Wolverhampton.
1896. *Hough, S. S., F.R.S. Royal Observatory, Cape Town.
1905. §Houghting, A. G. L. Glenelg, Musgrave-road, Durban, Natal.
1886. ‡Houghton, F. T. S., M.A., F.G.S. 188 Hagley-road, Edgbaston, Birmingham.
1887. ‡Houldsworth, Sir W. H., Bart., M.P. 35 Grosvenor-place, S.W.
1896. ‡Hoult, J. South Castle-street, Liverpool.
1905. §Houseman, C. L. P.O. Box 149, Johannesburg.
1884. ‡Houston, William. Legislative Library, Toronto, Canada.
1883. *Hovenden, Frederick, F.L.S., F.G.S. Glenlea, Thurlow Park-road, West Dulwich, S.E.
1893. ‡Howard, F. T., M.A., F.G.S. The Cottage, Poynton, Stockport.
1883. ‡Howard, James Fielden, M.D., M.R.C.S. Sandycroft, Shaw.
1887. *Howard, S. S. 58 Albemarle-road, Beckenham, Kent.
1899. ‡Howard-Hayward, H. 16 Blakesley-avenue, Ealing, W.
1901. §Howarth, E. Public Museum, Weston Park, Sheffield.
1903. *Howarth, James H., F.G.S. Somersley, Rawson-avenue, Halifax.
1886. ‡*Howatt, David. 3 Birmingham-road, Dudley.*
1876. ‡Howatt, James. 146 Buchanan-street, Glasgow.
1899. ‡Howden, Ian D. C. 6 Cambridge-terrace, Dover.
1889. ‡Howden, Robert, M.B., Professor of Anatomy in the University of Durham College of Medicine, Newcastle-upon-Tyne.
1857. ‡Howell, Henry H., F.G.S. 13 Cobden-crescent, Edinburgh.
1898. ‡Howell, J. H. 104 Pembroke-road, Clifton, Bristol.
1891. ‡Howell, Rev. William Charles, M.A. Holy Trinity Parsonage, High Cross, Tottenham, N.
1905. §Howick, Dr. W. P.O. Box 503, Johannesburg.
1901. ‡Howie, Robert Y. 3 Greenlaw-avenue, Paisley.
1865. *Howlett, Rev. Frederick, F.R.A.S. 7 Prince's-buildings, Clifton, Bristol.
1863. ‡Howorth, Sir H. H., K.C.I.E., D.C.L., F.R.S., F.S.A. 30 Collingham-place, Cromwell-road, S.W.
1883. ‡Hoyle, James. Blackburn.
1887. §Hoyle, William E., M.A., D.Sc. Victoria University, Manchester.
1903. §Hübner, Julius. Ash Villa, Cheadle Hulme, Cheshire.
1888. ‡Hudd, Alfred E., F.S.A. Clinton House, Pembroke-road, Clifton, Bristol.
1898. §Hudleston, W. H., M.A., F.R.S., F.G.S. (Pres. C, 1898.) 8 Stanhope-gardens, S.W.
1867. *Hudson, William H. H., M.A. 60 Altenburg-gardens, Clapham Common, S.W.
1858. *Huggins, Sir William, K.C.B., D.C.L. Oxon., LL.D. Camb., F.R.S., F.R.A.S. (President, 1891; Council, 1868–74, 1876–84.) 90 Upper Tulse-hill, S.W.
1887. ‡Hughes, E. G. 4 Roman-place, Higher Broughton, Manchester
1883. ‡Hughes, Miss E. P. Cambridge Teachers' College, Cambridge.
1871. *Hughes, George Pringle, J.P. Middleton Hall, Wooler, Northumberland.
1887. ‡Hughes, John Taylor. Thorleymoor, Ashley-road, Altrincham.
1896. ‡Hughes, John W. New Heys, Allerton, Liverpool.
1891. ‡Hughes, Thomas, F.C.S. 31 Loudoun-square, Cardiff.
1868. §Hughes, T. M'K., M.A., F.R.S., F.G.S. (Council 1879–86), Woodwardian Professor of Geology in the University of Cambridge. Ravensworth, Brooklands-avenue, Cambridge.
1891. ‡Hughes, Rev. W. Hawker. Jesus College, Oxford.

Year of Election.

1867. ‡HULL, EDWARD, M.A., LL.D., F.R.S., F.G.S. (Pres. C., 1874.) 14 Stanley-gardens, Notting Hill, W.
1903. ‡Hulton, Campbell G. Palace Hotel, Southport.
1905. §Hume, D. G. W. P.O. Box 1132, Johannesburg.
1897. ‡Hume, J. G., M.A., Ph.D. 650 Church-street, Toronto, Canada.
1901. ‡Hume, John H. Toronto, Canada; and 63 Bridgegate, Irvine.
1890. ‡*Humphrey, Frank W. 63 Prince's-gate, S.W.*
1904. *Humphreys, Alexander C., Sc.D., LL.D., President of the Stevens Institute of Technology, Hoboken, New Jersey, U.S.A.
1880. ‡Humphreys, Noel A., F.S.S. Ravenhurst, Hook, Kingston-on-Thames.
1877. *HUNT, ARTHUR ROOPE, M.A., F.G.S. Southwood, Torquay.
1891. *Hunt, Cecil Arthur. Southwood, Torquay.
1891. ‡Hunt, D. de Vere, M.D. Aubrey House, Cathedral-road, Cardiff.
1875. *Hunt, William. North Cote, Westbury-on-Trym, Bristol.
1881. ‡Hunter, F. W. Newbottle, Fence Houses, Co. Durham.
1889. ‡Hunter, Mrs. F. W. Newbottle, Fence Houses, Co. Durham.
1901. ‡Hunter, G. M., Assoc.M.Inst.C.E. Newyards, Maybole, N.B.
1881. ‡Hunter, Rev. John. University-gardens, Glasgow.
1901. *Hunter, William. Evirallan, Stirling.
1879. ‡HUNTINGTON, A. K., F.C.S., Professor of Metallurgy in King's College, W.C.
1885. ‡Huntly, The Most Hon. the Marquess of. Aboyne Castle, Aberdeenshire.
1863. ‡Huntsman, Benjamin. West Retford Hall, Retford.
1898. ‡Hurle, J. Cooke. Southfield House, Brislington, Bristol.
1903. §Hurst, Charles C., F.L.S. Burbage, Hinckley.
1882. *Hurst, Walter, B.Sc. Kirkgate, Tadcaster, Yorkshire.
1861. *Hurst, William John. Drumaness, Ballynahinch, Co. Down, Ireland.
1905. §Hutcheon, Duncan, M.R.C.V.S. Department of Agriculture, Cape Town.
1894. *HUTCHINSON, A., M.A., Ph.D. (Local Sec. 1904.) Pembroke College, Cambridge.
1903. §Hutchinson, Rev. H. N. 94 Fellows-road, N.W.
Hutton, Crompton. Harescombe Grange, Stroud, Gloucestershire.
1864. *Hutton, Darnton. 14 Cumberland-terrace, Regent's Park, N.W.
1887. *Hutton, J. Arthur. The Woodlands, Alderley Edge, Cheshire.
1901. *Hutton, R. S., M.Sc. The Victoria University, Manchester.
1883. ‡Hyde, George H. 23 Arbour-street, Southport.
1871. *Hyett, Francis A. Painswick House, Painswick, Stroud, Gloucestershire.
1900. *Hyndman, H. H. Francis. Physical Laboratory, Leiden, Netherlands.
1902. ‡Hyndman, Hugh. Crosshill, Windsor-avenue, Belfast.

1883. §Idris, T. H. W. 110 Pratt-street, Camden Town, N.W.
Ihne, William, Ph.D. Heidelberg.
1884. *Iles, George. 5 Brunswick-street, Montreal, Canada.
1885. ‡im Thurn, Sir Everard F., C.B., K.C.M.G. Colombo, Ceylon.
1888. *Ince, Surgeon-Lieut.-Col. John, M.D. Montague House, Swanley, Kent.
1905. §Ingham, W. Engineer's Office, Sand River, Uitenhage.
1893. ‡Ingle, Herbert. Department of Agriculture, Pretoria.
1901. ‡INGLIS, JOHN, LL.D. 4 Prince's-terrace, Dowanhill, Glasgow.
1891. ‡Ingram, Lieut.-Colonel C. W. Bradford-place, Penarth.

Year of
Election.

1852. ‡INGRAM, J. K., LL.D., M.R.I.A. (Pres. F. 1878), Senior Lecturer in the University of Dublin. 2 Wellington-road, Dublin.
1885. ‡Ingram, William, M.A. Gamrie, Banff.
1905. §Innes, Miss Mary. St. Albans, Wellington-street, Cheltenham.
1905. §Innes, R. T. A., F.R.A.S. Meteorological Observatory, Johannesburg.
1898. ‡Inskip, James. Clifton Park, Clifton, Bristol.
1901. *Ionides, Stephen A. 23 Second-avenue, Hove, Brighton.
1892. ‡Irvine, James. Devonshire-road, Birkenhead.
1882. §IRVING, Rev. A., B.A., D.Sc. Hockerill Vicarage, Bishop's Stortford, Herts.
1903. ‡Irving, W. B. 27 Park-road, Southport.
1905. §Iwasaki, Koyata. Pembroke College, Cambridge.

1859. ‡Jack, John, M.A. Belhelvie-by-Whitecairns, Aberdeenshire.
1876. *JACK, WILLIAM, LL.D., Professor of Mathematics in the University of Glasgow. 10 The College, Glasgow.
1901. §Jacks, William, LL.D. The Gart, Callander.
1883. *JACKSON, Professor A. H., B.Sc. 349 Collins-street, Melbourne, Australia.
1903. §Jackson, C. S. 96 Herbert-road, Woolwich, S.E.
1883. *Jackson, F. J. 35 Leyland-road, Southport.
1883. ‡Jackson, Mrs. F. J. 35 Leyland-road, Southport.
1874. *Jackson, Frederick Arthur. Belmont, Somenos, Vancouver Island, B.C., Canada.
1899. ‡Jackson, Geoffrey A. 31 Harrington-gardens, Kensington, S.W.
1897. §Jackson, James, F.R.Met.Soc. Seabank, Girvan, N.B.
1898. *Jackson, Sir John. 51 Victoria-street, S.W.
1869. ‡Jackson, Moses, J.P. The Orchards, Whitchurch, Hants.
1905. §Jacobsohn, Lewis B. Lloyd's-buildings, 58 Burg-street, Cape Town.
1905. §Jacobsohn, Sydney Samuel. Lloyd's-buildings, 58 Burg-street, Cape Town.
1887. §Jacobson, Nathaniel. Olive Mount, Cheetham Hill-road, Manchester.
1905. *Jaffé, Arthur, B.A. Strandtown, Belfast.
1874. *Jaffe, John. Villa Jaffe, 38 Prom. des Anglais, Nice, France.
1905. §Jagger, J. W. St. George's-street, Cape Town.
1891. ‡James, Arthur P. Grove House, Park-grove, Cardiff.
1891. *James, Charles Henry, J.P. 64 Park-place, Cardiff.
1891. *James, Charles Russell. 5 Raymond-buildings, Gray's Inn, W.C.
1860. ‡James, Edward H. Woodside, Plymouth.
1891. ‡James, Ivor. University College, Cardiff.
1896. ‡James, O. S. 192 Jarvis-street, Toronto, Canada.
1904. §James, Thomas Campbell. University College, Aberystwyth.
1858. ‡James, William C. Woodside, Plymouth.
1905. §Jameson, Adam. Office of the Commissioner of Lands, Pretoria.
1896. **Jameson, H. Lyster, M.A., Ph.D. Technical College, Derby.*
1884. ‡Jameson, W. C. 48 Baker-street, Portman-square, W.
1881. ‡Jamieson, Andrew, Principal of the College of Science and Arts, Glasgow.
1885. ‡Jamieson, Thomas. 173 Union-street, Aberdeen.
1859. *Jamieson, Thomas F., LL.D., F.G.S. Ellon, Aberdeenshire.
1889. *JAPP, F. R., M.A., Ph.D., LL.D., F.R.S. (Pres. B, 1898), Professor of Chemistry in the University of Aberdeen.
1896. *Jarmay, Gustav. Hartford Lodge, Hartford, Cheshire.

Year of Election.

1903. ‡JARRATT, J. ERNEST. (Local Sec. 1903.) 10 Cambridge-road, Southport.
1870. ‡Jarrold, John James. London-street, Norwich.
1904. *Jeans, J. H. Princeton, New Jersey, U.S.A.
1891. ‡Jefferies, Henry. Plas Newydd, Park-road, Penarth.
1897. ‡Jeffrey, E. C., B.A. The University, Toronto, Canada.
1894. ‡Jelly, Dr. W. Aveleanas, 11, Valencia, Spain.
1873. ‡Jenkins, Major-General J. J. 16 St. James's-square, S.W.
1880. *JENKINS, Sir JOHN JONES. The Grange, Swansea.
1903. ‡Jenkinson, J. W. The Museum, Oxford.
1904. ‡Jenkinson, W. W. 6 Moorgate-street, E.C.
1852. ‡Jennings, Francis M., M.R.I.A. Brown-street, Cork.
1893. §Jennings, G. E. Glen Helen, Narborough-road, Leicester.
1905. §Jennings, Sydney. P.O. Box 149, Johannesburg.
1897. ‡Jennings, W. T., M.Inst.CE. Molson's Bank Buildings, Toronto, Canada.
1899. ‡Jepson, Thomas. Evington, Northumberland-street, Higher Broughton, Manchester.
1905. §Jerome, Charles. P.O. Box 83, Johannesburg.
1887. ‡JERVIS-SMITH, Rev. F. J., M.A., F.R.S. Trinity College, Oxford.
Jessop, William. Overton Hall, Ashover, Chesterfield.
1889. ‡Jevons, F. B., M.A. The Castle, Durham.
1900. *Jevons, H. Stanley. 19 Chesterfield-gardens, Hampstead, N.W.
1905. §Jeyes, Miss Gertrude, B.A. 22 Cumberland-road, Kew.
1905. §Jobson, J. B. P.O. Box 3341, Johannesburg.
1884. ‡Johns, Thomas W. Yarmouth, Nova Scotia, Canada.
1884. ‡JOHNSON, ALEXANDER, M.A., LL.D., Professor of Mathematics in McGill University, Montreal. 5 Prince of Wales-terrace, Montreal, Canada.
1883. ‡*Johnson, Miss Alice, Llandaff House, Cambridge.*
1865. *Johnson, G. J. 36 Waterloo-street, Birmingham.
1888. ‡Johnson, J. G. Southwood Court, Highgate, N.
1881. ‡Johnson, Sir Samuel George. Municipal Offices, Nottingham.
1890. *JOHNSON, THOMAS, D.Sc., F.L.S., Professor of Botany in the Royal College of Science, Dublin.
1902. *Johnson, Rev. W., B.A., B.Sc. Archbishop Holgate's Grammar School, York.
1898. *Johnson, W. Claude, M.Inst.C.E. The Studio, Westbourne-street, W.
1887. ‡Johnson, W. H. Woodleigh, Altrincham, Cheshire.
1883. ‡Johnson, W. H. F. Llandaff House, Cambridge.
1861. ‡Johnson, William Beckett. Woodlands Bank, near Altrincham, Cheshire.
1899. ‡Johnston, Colonel Duncan A., C.B., R.E. Ordnance Survey, Southampton.
1883. ‡JOHNSTON, Sir H. H., G.C.M.G., K.C.B., F.R.G.S. Queen Anne's-mansions, S.W.
1884. ‡Johnston, John L. 27 St. Peter-street, Montreal, Canada.
1883 ‡Johnston, Thomas. Broomsleigh, Seal, Sevenoaks.
1884. *Johnston, W. H. County Offices, Preston, Lancashire.
1884. ‡Johnston, Walter R. Fort Qu'Appelle, N.W. Territory, Canada.
1885. ‡JOHNSTON-LAVIS, H. J., M.D., F.G.S. Beaulieu, Alpes Maritimes, France.
1886. ‡Johnstone, G. H. Northampton-street, Birmingham.
1871. ‡JOLLY, WILLIAM, F.R.S.E., F.G.S. Blantyre Lodge, Blantyre, N.B.
1888. ‡*Jolly, W. C. Home Lea, Lansdowne, Bath.*

Year of Election.

1896. *Joly, Charles Jasper, M.A., D.Sc., F.R.S., F.R.A.S., Royal, Astronomer of Ireland and Andrews Professor of Astronomy in the University of Dublin. The Observatory, Dunsink, Co. Dublin.

1888. ‡Joly, John, M.A., D.Sc., F.R.S., F.G.S., Professor of Geology and Mineralogy in the University of Dublin. Geological Department, Trinity College, Dublin.

1898. ‡Jones, Sir Alfred L., K.C.M.G. Care of Messrs. Elder, Dempster, & Co., Liverpool.

1887. ‡Jones, D. E., B.Sc., H.M. Inspector of Schools. Science and Art Department, South Kensington, S.W.

1904. §Jones, Miss E. Constance. Girton College, Cambridge.

1890. §Jones, Rev. Edward, F.G.S. Primrose Cottage, Embsay, Skipton.

1896. ‡Jones, E. Taylor, D.Sc. University College, Bangor.

1903. §Jones, Evan. Ty-Mawr, Aberdare.

1887. ‡Jones, Francis, F.R.S.E., F.C.S. Beaufort House, Alexandra Park, Manchester.

1891. *Jones, Rev. G. Hartwell, M.A. Nutfield Rectory, Redhill, Surrey.

1883. *Jones, George Oliver, M.A. Inchyra House, 21 Cambridge-road, Waterloo, Liverpool.

1903. *Jones, H. O., M.A. Clare College, Cambridge.

1895. ‡Jones, Harry. Engineer's Office, Great Eastern Railway, Ipswich.

1877. ‡Jones, Henry C., F.C.S. Royal College of Science, South Kensington, S.W.

1901. §Jones, R. E., J.P. Oakley Grange, Shrewsbury.

1902. ‡Jones, R. M., M.A. Royal Academical Institution, Belfast.

1905. §Jones, Miss Parnell. The Rectory, Llanddewi Skirrid, Abergavenny, Monmouthshire.

1873. ‡Jones, Theodore B. 1 Finsbury-circus, E.C.

1880. ‡Jones, Thomas. 15 Gower-street, Swansea.

1860. ‡Jones, Thomas Rupert, F.R.S., F.G.S. (Pres. C, 1891.) Penbryn, Chesham Bois-lane, Chesham, Bucks.

1896. ‡Jones, W. Hope Bank, Lancaster-road, Pendleton, Manchester.

1883. ‡Jones, William. Elsinore, Birkdale, Southport.

1875. *Jose, J. E. 49 Whitechapel, Liverpool.

1884. ‡Joseph, J. H. 738 Dorchester-street, Montreal, Canada.

1891. ‡Jotham, F. H. Penarth.

1891. ‡Jotham, T. W. Penylan, Cardiff.

1879. ‡Jowitt, A. Scotia Works, Sheffield.

1890. ‡Jowitt, Benson R. Elmhurst, Newton-road, Leeds.

1872. ‡Joy, Algernon. Junior United Service Club, St. James's, S.W.

1883. ‡Joyce, Rev. A. G., B.A. St. John's Croft, Winchester.

1886. ‡Joyce, The Hon. Mrs. St. John's Croft, Winchester.

1891. ‡Joynes, John J. Great Western Colliery, near Coleford, Gloucestershire.

1905. §Judd, Miss Hilda M., B.Sc. 22 Cumberland-road, Kew.

1870. ‡Judd, John Wesley, C.B., LL.D., F.R.S., F.G.S. (Pres. C, 1885; Council, 1886–92.) 22 Cumberland-road, Kew.

1903. §Julian, Henry Forbes. Redholme, Braddon's Hill-road, Torquay.

1894. §Julian, Mrs. Forbes. Redholme, Braddon's Hill-road, Torquay.

1905. §Juritz, C. F., M.A. Villa Marina, Sea Point, Cape Colony.

1883. ‡Justice, Philip Middleton. 14 Southampton-buildings, Chancery-lane, W.C.

1888. ‡Kapp, Gisbert, M.Inst.C.E., M.Inst.E.E. 3 Lindenallee, Westend, Berlin.

Year of Election.

1904. ‡Kayser, Professor H. The University, Bonn, Germany.
1875. ‡Keeling, George William. Tuthill, Lydney.
1886. ‡Keen, Arthur, J.P. Sandyford, Augustus-road, Birmingham.
1878. *Kelland, W. H. 80 Lothian-road, S.W.
1884. ‡Kellogg, J. H., M.D. Battle Creek, Michigan, U.S.A.
1864. *Kelly, W. M., M.D. Ferring, near Worthing.
1902. *Kelly, William J., J.P. 25 Oxford-street, Belfast.
1885. §KELTIE, J. SCOTT, LL.D., Sec. R.G.S., F.S.S. (Pres. E, 1897; Council, 1898–1904.) 1 Savile-row, W.
1847. *KELVIN, The Right Hon. Lord, G.C.V.O., M.A., LL.D., D.C.L., F.R.S., F.R.S.E., F.R.A.S. (PRESIDENT, 1871; Pres. A, 1852, 1867, 1876, 1881, 1884.) Netherhall, Largs, Ayrshire; and 15 Eaton-place, S.W.
1877. *Kelvin, Lady. Netherhall, Largs, Ayrshire; and 15 Eaton-place, S.W.
1887. ‡Kemp, Harry. 55 Wilbraham-road, Chorlton-cum-Hardy, Manchester.
1898. *Kemp, John T., M.A. 4 Cotham-grove, Bristol.
1884. ‡Kemper, Andrew C., A.M., M.D. 101 Broadway, Cincinnati, U.S.A.
1890. ‡Kempson, Augustus. Kildare, 17 Arundel-road, Eastbourne.
1891. ‡KENDALL, PERCY F., F.G.S., Professor of Geology in the University of Leeds.
1875. ‡KENNEDY, Sir ALEXANDER B. W., LL.D., F.R.S., M.Inst.C.E. (Pres. G, 1894.) 1 Queen Anne-street, Cavendish-square, W.
1897. §Kennedy, George, M.A., LL.D. Crown Lands Department, Toronto, Canada.
1884. †Kennedy, George T., M.A., F.G.S., Professor of Chemistry and Geology in King's College, Windsor, Nova Scotia, Canada.
1876. ‡Kennedy, Hugh. 20 Mirkland-street, Glasgow.
1884. ‡Kennedy, John. 113 University-street, Montreal, Canada.
1884. ‡Kennedy, William. Hamilton, Ontario, Canada.
1905. *Kennerley, W. R. P.O. Box 158, Pretoria.
1886. ‡Kenrick, George Hamilton. Whetstone, Somerset-road, Edgbaston, Birmingham.
1893. §KENT, A. F. STANLEY, M.A., F.L.S., F.G.S., Professor of Physiology in University College, Bristol.
1901. ‡Kent, G. 16 Premier-road, Nottingham.
1886. §KENWARD, JAMES, F.S.A. 12 Marine-Parade North, Great Yarmouth.
1857. *Ker, André Allen Murray. Newbliss House, Newbliss, Ireland.
1876. ‡Ker, William. 1 Windsor-terrace West, Glasgow.
1881. ‡KERMODE, PHILIP M. C. Claughbane, Ramsey, Isle of Man.
1884. ‡Kerr, James, M.D. Winnipeg, Canada.
1883. ‡KERR, REV. JOHN, LL.D., F.R.S. Free Church Training College, 113 Hill-street, Glasgow.
1901. ‡Kerr, John G., LL.D. 15 India-street, Glasgow.
1892. †KERR, J. GRAHAM, M.A., Professor of Natural History in the University, Glasgow.
1889. ‡Kerry, W. H. R. The Sycamores, Windermere.
1887. ‡Kershaw, James. Holly House, Bury New-road, Manchester.
1869. *Kesselmeyer, Charles Augustus. Rose Villa, Vale-road, Bowdon, Cheshire.
1869. *Kesselmeyer, William Johannes. Elysée Villa, Manchester-road, Altrincham, Cheshire.
1903. §Kewley, James. King William's College, Isle of Man.
1883. *Keynes, J. N., M.A., D.Sc., F.S.S. 6 Harvey-road, Cambridge.
1905. §Kidd, Professor A. Stanley. Rhodes University College, Grahamstown, Cape Colony.

Year of Election.

1902. §Kidd, George. Greenhaven, Malone Park, Belfast.
1876. ‡Kidston, J. B. 50 West Regent-street, Glasgow.
1886. §KIDSTON, ROBERT, F.R.S., F.R.S.E., F.G.S. 12 Clarendon-place, Stirling.
1897. ‡Kiekelly, Dr. John, LL.D. 46 Upper Mount-street, Dublin.
1901. *Kiep, J. N. 4 Hughenden-drive, Kelvinside, Glasgow.
1885. *Kilgour, Alexander. Loirston House, Cove, near Aberdeen.
1896. *Killey, George Deane. Bentuther, 11 Victoria-road, Waterloo, Liverpool.
1890. §KIMMINS, C. W., M.A., D.Sc. Dame Armstrong House, Harrow.
1878. ‡Kinahan, Sir Edward Hudson, Bart. 11 Merrion-square North, Dublin.
1860. ‡KINAHAN, G. HENRY, M.R.I.A. Dublin.
1905. §Kincaid, Major-General W. Care of Messrs. Alexander, Fletcher, & Co., 2 St. Helen's-place, Bishopsgate-street, E.C.
1905. §Kincaid, Mrs. Care of Messrs. Alexander, Fletcher, & Co., 2 St. Helen's-place, Bishopsgate-street, E.C.
1875. *KINCH, EDWARD, F.C.S. Royal Agricultural College, Cirencester.
1888. ‡King, Austin J. Winsley Hill, Limpley Stoke, Bath.
1888. *King, E. Powell. Wainsford, Lymington, Hants.
1875. *King, F. Ambrose. Avonside, Clifton, Bristol.
1899. ‡KING, Sir GEORGE, K.C.I.E., F.R.S. (Pres. K, 1899). Care of Messrs. Grindlay & Co., Parliament-street, S.W.
1871. *King, Rev. Herbert Poole. The Rectory, Stourton, Bath.
1855. ‡King, James. Levernholme, Hurlet, Glasgow.
1883. *King, John Godwin. Stonelands, West Hoathly.
1870. ‡King, John Thomson. 4 Clayton-square, Liverpool.
1883. *King, Joseph. Sandhouse, Witley, Godalming.
1860. *King, Mervyn Kersteman. Merchants' Hall, Bristol.
1875. *King, Percy L. 2 Worcester-avenue, Clifton, Bristol.
1901. ‡King, Robert. Levernholme, Nitshill, Glasgow.
1870. ‡King, William, M.Inst.C.E. 5 Beach Lawn, Waterloo, Liverpool.
1903. §Kingsford, H. S., M.A. Anthropological Institute, 3 Hanover-square, W.
1897. ‡Kingsmill, Nichol. Toronto, Canada.
1875. ‡KINGZETT, CHARLES T., F.C.S. Elmstead Knoll, Chislehurst.
1867. ‡Kinloch, Colonel. Kirriemuir, Logie, Scotland.
1892. ‡Kinnear, The Hon. Lord, F.R.S.E. 2 Moray-place, Edinburgh.
1900. ‡KIPPING, Professor F. STANLEY, D.Sc., Ph.D., F.R.S. University College, Nottingham.
1899. *Kirby, Miss C. F. 74 Kensington Park-road, W.
1905. §Kirkby, Reginald G. P.O. Box 7, Pietermaritzburg, Natal.
1870. ‡*Kitchener, Frank E. Newcastle, Staffordshire.*
1904. ‡*Kitson, Arthur. 209 Gloucester-terrace, Hyde Park, W.*
1890. *KITSON, Sir JAMES, Bart., M.P. Gledhow Hall, Leeds.
1901. §Kitto, Edward. The Observatory, Falmouth.
1886. ‡Klein, Rev. L. M. de Beaumont, D.Sc., F.L.S. 6 Gloucester-terrace, Regent's Park, N.W.
1886. ‡Knight, J. McK., F.G.S. Bushwood, Wanstead, Essex.
1905. §Knightley, Lady, of Fawsley. Fawsley Park, Daventry.
1898. ‡KNOCKER, Sir E. WOLLASTON, K.C.B. (Local Sec. 1899.) Castle Hill House, Dover.
1888. ‡KNOTT, Professor CARGILL G., D.Sc., F.R.S.E. 42 Upper Gray-street, Edinburgh.
1887. *Knott, Herbert. Aingarth, Stalybridge, Cheshire.
1887. *Knott, John F. St. Martins, Hooton, near Chester.
1874. ‡Knowles, William James. Flixton-place, Ballymena, Co. Antrim.
1903. ‡Knowlson, J. F. 26 Part-street, Southport.

Year of Election.

1897. ‡Knowlton, W. H. 36 King-street East, Toronto, Canada.
1876. ‡Knox, David N., M.A., M.B. 24 Elmbank-crescent, Glasgow.
1902. ‡KNOX, R. KYLE, LL.D. 1 College-gardens, Belfast.
1875. *Knubley, Rev. E. P., M.A. Steeple Ashton Vicarage, Trowbridge.
1883. ‡Knubley, Mrs. Steeple Ashton Vicarage, Trowbridge.
1905. §Koenig, J. P.O. Box 272, Cape Town.
1892. ‡KOHN, CHARLES A., Ph.D. Sir John Cass Technical Institute, Jewry-street, Aldgate, E.C.
1898. ‡Krauss, A. Hawthornden, Priory-road, Clifton, Bristol.
1890. *Krauss, John Samuel, B.A. Stonycroft, Knutsford-road, Wilmslow, Cheshire.
1901. ‡Kuenen, Professor J. P., Ph.D. University College, Dundee.
1888. *Kunz, G. F., M.A., Ph.D. Care of Messrs. Tiffany & Co., 11 Union-square, New York City, U.S.A.
1870. ‡Kynaston, Josiah W., F.C.S. 3 Oak-terrace, Beech-street, Liverpool.

1905. §Lacey, William. Champ d'Or Gold Mining Co., Luipaardsvlei, Transvaal.
1885. *Laing, J. Gerard. 5 Pump-court, Temple, E.C.
1897. ‡Laird, Professor G. J. Wesley College, Winnipeg, Canada.
1904. ‡Lake, Philip. St. John's, College, Cambridge.
1877. ‡Lake, W. C., M.D. Teignmouth.
1904. ‡Lamb, C. G. Ely Villa, Glisson-road, Cambridge.
1889. *Lamb, Edmund, M.A. Borden Wood, Liphook, Hants.
1887. ‡LAMB, HORACE, M.A., LL.D., D.Sc., F.R.S. (Pres. A, 1904), Professor of Pure Mathematics in the Victoria University, Manchester. 6 Wilbraham-road, Fallowfield, Manchester.
1887. ‡Lamb, James. Kenwood, Bowdon, Cheshire.
1896. ‡Lambert, Frederick Samuel. Balgowan, Newland, Lincoln.
1893. ‡Lambert, J. W., J.P. Lenton Firs, Nottingham.
1903. ‡Lambert, Joseph. 9 Westmoreland-road, Southport.
1884. ‡Lamborn, Robert H. Montreal, Canada.
1893. *LAMPLUGH, G. W., F.R.S., F.G.S. 13 Beaconsfield-road, St. Albans.
1871. ‡Lancaster, Edward. Karesforth Hall, Barnsley, Yorkshire.
1886. ‡Lancaster, W. J., F.G.S. Colmore-row, Birmingham.
1905. §Lane, Rev. C. A. P.O. Box 326, Johannesburg.
1883. ‡Lang, Rev. Gavin. Mayfield, Inverness.
1859. ‡Lang, Rev. John Marshall, D.D. The University, Aberdeen.
1898. *Lang, William H. 10 Jedburgh-gardens, Kelvinside, Glasgow.
1905. §Lange, John H. Judges' Chambers, Kimberley.
1886. *LANGLEY, J. N., M.A., D.Sc., F.R.S. (Pres. I, 1899; Council, 1904–), Professor of Physiology in the University of Cambridge. Trinity College, Cambridge.
1870. ‡Langton, Charles. Barkhill, Aigburth, Liverpool.
1865. ‡LANKESTER, E. RAY, M.A., LL.D., D.Sc., F.R.S. (PRESIDENT ELECT; Pres. D, 1883; Council 1889–90, 1894–95, 1900–02), Director of the Natural History Museum, Cromwell-road, S.W.
1880. *LANSDELL, Rev. HENRY, D.D., F.R.A.S., F.R.G.S. Morden College, Blackheath, London, S.E.
1884. §Lanza, Professor G. Massachusetts Institute of Technology, Boston, U.S.A.
1878. ‡Lapper, E., M.D. 61 Harcourt-street, Dublin.
1885. ‡LAPWORTH, CHARLES, LL.D., F.R.S., F.G.S. (Pres. C, 1892), Professor of Geology and Physiography in the University of Birmingham. 48 Frederick-road, Edgbaston, Birmingham.
1887. ‡Larmor, Alexander. Craglands, Helen's Bay, Co. Down.

Year of Election.

1881. ‡LARMOR, JOSEPH, M.A., D.Sc., Sec.R.S. (Pres. A, 1900), Lucasian Professor of Mathematics in the University of Cambridge. St. John's College, Cambridge.
1883. §Lascelles, B. P., M.A. Longridge, Harrow.
1896. *Last, William J. South Kensington Museum, London, S.W.
1870. *LATHAM, BALDWIN, M.Inst.C.E., F.G.S. 7 Westminster-chambers, Westminster, S.W.
1900. ‡Lauder, Alexander, Lecturer in Agricultural Chemistry in the Edinburgh and East of Scotland College of Agriculture, Edinburgh.
1870. ‡Laughton, John Knox, M.A., F.R.G.S. 5 Pepys-road, Wimbledon, Surrey.
1891. ‡Laurie, A. P. Heriot Watt College, Edinburgh.
1892. ‡LAURIE, MALCOLM, B.A., D.Sc., F.L S. School of Medicine, Surgeons' Hall, Edinburgh.
1883. ‡Laurie, Major-General. Oakfield, Nova Scotia, Canada.
1870. *Law, Channell. Ilsham Dene, Torquay.
1884. ‡Law, Robert, F.G.S. Fennyroyd Hall, Hipperholme, near Halifax, Yorkshire.
1870. ‡*Lawrence, Edward. Aigburth, Liverpool.*
1881. ‡Lawrence, Rev. F., B.A. The Vicarage, Westow, York.
1905. §Lawrence, Miss M. Roedean School, near Brighton.
1900. ‡Lawrence, W. Trevor, Ph.D. 57 Prince's-gate, S.W.
1885. ‡Lawson, James. 8 Church-street, Huntly, N.B.
1888. §Layard, Miss Nina F. Rookwood, Tonnereau-road, Ipswich.
1856. ‡Lea, Henry. 38 Bennett's-hill, Birmingham.
1883. *Leach, Charles Catterall. Seghill, Northumberland.
1875. ‡Leach, Colonel Sir G., K.C.B., R.E. 6 Wetherby-gardens, S.W.
1894. *LEAHY, A. H., M.A., Professor of Mathematics in the University of Sheffield. 92 Ashdell-road, Sheffield.
1884. *Leahy, John White, J.P. South Hill, Killarney, Ireland.
1905. §Leake, E. O. 5 Harrison-street, Johannesburg.
1901. *Lean, George, B.Sc. 15 Park-terrace, Glasgow.
1884. ‡Learmont, Joseph B. 120 Mackay-street, Montreal, Canada.
1904. *Leathem, J. G. St. John's College, Cambridge.
1884. *Leavitt, Erasmus Darwin. 2 Central-square, Cambridgeport, Massachusetts, U.S.A.
1872. ‡LEBOUR, G. A., M.A., F.G.S., Professor of Geology in the Durham College of Science, Newcastle-on-Tyne.
1884. ‡Leckie, R. G. Springhill, Cumberland County, Nova Scotia, Canada.
1895. *Ledger, Rev. Edmund. Protea, Doods-road, Reigate.
1905. §Lee, Arthur. 1 Corrowdore-terrace, Main-road, Three Anchor Bay, Cape Colony.
1898. ‡LEE, ARTHUR, J.P. (Local Sec. 1898). 10 Berkeley-square, Clifton, Bristol.
1896. §Lee, Rev. H. J. Barton. 35 Cross Park-terrace, Heavitree, Exeter.
1894. *Lee, Mrs. W. Ashdown House, Forest Row, Sussex.
1884. *Leech, Sir Bosdin T. Oak Mount, Timperley, Cheshire.
1905. §Lees, Mrs. A. P. Care of Parr's Bank, York-street, Manchester.
1892. *LEES, CHARLES H., D.Sc. Heather Lea, Birch-grove, Rusholme, Manchester.
1886. *Lees, Lawrence W. Old Ivy House, Tettenhall, Wolverhampton.
1905. §Lees, R. Wilfrid. Pigg's Peak Development Co., Swaziland, South Africa.
1859. ‡Lees, William, M.A. 12 Morningside-place, Edinburgh.
1896. ‡Lees, William. 10 Norfolk-street, Manchester.
*Leese, Joseph. 3 Lord-street West, Southport.

Year of Election.

1889. *Leeson, John Rudd, M.D., C.M., F.L.S., F.G.S. Clifden House, Twickenham, Middlesex.
1881. ‡LE FEUVRE, J. E. (Local Sec. 1882). Southampton.
1872. ‡LEFEVRE, The Right Hon. G. SHAW, F.R.S. (Pres. F, 1879; Council 1878–80.) 18 Bryanston-square, W.
1869. ‡Le Grice, A. J. Trereife, Penzance.
1905. §Legg, W. A. P.O. Box 1621, Cape Town.
1892. ‡LEHFELDT, ROBERT A. 56 Norfolk-square, W.
1868. ‡LEICESTER, The Right Hon. the Earl of, K.G. Holkham, Norfolk.
1891. ‡Leigh, W. W. Treharris, R.S.O., Glamorganshire.
1903. ‡Leighton, G. R., M.D., F.R.S.E., Professor of Pathology in the Royal Veterinary College, Edinburgh.
1905. §Leitch, Donald. P.O. Box 1703, Johannesburg.
1859. ‡Leith, Alexander. Glenkindie, Inverkindie, N.B.
1882. §Lemon, James, M.Inst.C.E., F.G.S. Lansdowne House, Southampton.
1903. *Lempfort, R. G. K., M.A. Meteorological Office, 63 Victoria-street, S.W.
1867. ‡Leng, Sir John, M.P. 'Advertiser' Office, Dundee.
1878. ‡Lennon, Rev. Francis. The College, Maynooth, Ireland.
1902. ‡Lennox, R. N. Rosebank, Hammersmith, W.
1887. *Leon, John T. Elmwood, Grove-road, Southsea.
1871. ‡LEONARD, HUGH, M.R.I.A. 24 Mount Merrion-avenue, Blackrock, Co. Dublin.
1901. §Leonard, J. H., B.Sc. 2 Carlingford-road, Hampstead, N.W.
1905. §Leonard, Right Rev. Bishop John. St. Mary's, Cape Town.
1904. ‡Lepper, Alfred William. 6 Trinity College, Dublin.
1884. ‡Lesage, Louis. City Hall, Montreal, Canada.
1890. *Lester, Joseph Henry. Royal Exchange, Manchester.
1883. ‡Lester, Thomas. Fir Bank, Penrith.
1904. *Le Sueur, H. R., D.Sc. Chemical Laboratory, St. Thomas's Hospital, S.E.
1900. ‡Letts, Professor E. A., D.Sc., F.R.S.E. Queen's College, Belfast.
1894. ‡Leudesdorf, Charles. Pembroke College, Oxford.
1896. ‡Lever, W. H. Port Sunlight, Cheshire.
1905. §Levin, Benjamin. P.O. Box 74, Cape Town.
1887. *Levinstein, Ivan. Hawkesmoor, Fallowfield, Manchester.
1890. ‡Levy, J. H. 11 Abbeville-road, Clapham Park, S.W.
1893. *LEWES, VIVIAN B., F.C.S., Professor of Chemistry in the Royal Naval College, Greenwich, S.E.
1879. ‡Lewin, Colonel, F.R.G.S. Garden Corner House, Chelsea Embankment, S.W.
1905. §Lewin, J. B. Duncan's-chambers, Shortmarket-street, Cape Town.
1870. ‡LEWIS, ALFRED LIONEL. 54 Highbury-hill, N.
1891. ‡Lewis, D., J.P. 44 Park-place, Cardiff.
1891. §Lewis, Professor D. Morgan, M.A. University College, Aberystwyth.
1899. ‡Lewis, Professor E. P. University of California, Berkeley, U.S.A.
1905. §Lewis, F. S. South African Public Library, Cape Town.
1904. ‡Lewis, Hugh. Glanafrau, Newton, Montgomeryshire.
1897. ‡Lewis, Rev. J. Pitt, M.A. Rossin House, Toronto, Canada.
1899. ‡Lewis, Thomas. 9 Hubert-terrace, Dover.
1891. ‡Lewis, W. 22 Duke-street, Cardiff.
1891. ‡Lewis, W. Henry. Bryn Rhos, Llanishen, Cardiff.
1884. *Lewis, Sir W. T., Bart. The Mardy, Aberdare.
1903. §Lewkowitsch, Dr. J. 71 Priory-road, N.W.
1878. ‡Lincolne, William. Ely, Cambridgeshire.

Year of
Election.

1871. ‡Lindsay, Rev. T. M., M.A., D.D. Free Church College, Glasgow.
1904. §Link, Charles W. 14 Chichester-road, Croydon.
1898. §Lippincott, R. C. Cann. Over Court, Almondsbury, near Bristol.
1895. *LISTER, The Right Hon. Lord, F.R.C.S., D.C.L., D.Sc., F.R.S. (PRESIDENT, 1896.) 12 Park-crescent, Portland-place, W.
1888. ‡LISTER, J. J., M.A., F.R.S. St. John's College, Cambridge.
1861. *LIVEING, G. D., M.A., F.R.S. (Pres. B, 1882; Council 1888–95; Local Sec. 1862), Professor of Chemistry in the University of Cambridge. Newnham, Cambridge.
1876. *LIVERSIDGE, ARCHIBALD, M.A., F.R.S., F.C.S., F.G.S., F.R.G.S., Professor of Chemistry in the University of Sydney, N.S.W.
1902. §Llewellyn, Evan. Working Men's Institute and Hall, Blaenavon.
1880. ‡LLEWELYN, Sir JOHN T. D., Bart., M.P. Penllegare, Swansea.
1903. ‡Lloyd, Godfrey I. H. Grindleford, near Sheffield.
1886. ‡Lloyd, J. Henry. Ferndale, Carpenter-road, Edgbaston, Birmingham.
1891. *LLOYD, R. J., M.A., D.Litt., F.R.S.E. 49A Grove-street, Liverpool.
1886. ‡Lloyd, Samuel. Farm, Sparkbrook, Birmingham.
1865. *Lloyd, Wilson, F.R.G.S. Park Lane House, Wednesbury.
1854. *LOBLEY, J. LOGAN, F.G.S., F.R.G.S. 36 Palace-street, Buckingham Gate, S.W.
1892. ‡LOCH, C. S., B.A. Denison House, Vauxhall Bridge-road, S.W.
1905. §Lochrane, Miss T. 8 Prince's-gardens, Dowanhill, Glasgow.
1904. ‡Lock, Rev. J. B. Herschel House, Cambridge.
1892. ‡Lockhart, Robert Arthur. 10 Polwarth-terrace, Edinburgh.
1863. ‡LOCKYER, Sir J. NORMAN, K.C.B., LL.D., F.R.S. (PRESIDENT, 1903; Council 1871–76, 1901–02.) 16 Penywern-road, S.W.
1902. *Lockyer, Lady. 16 Penywern-road, S.W.
1900. §LOCKYER, W. J. S., Ph.D. 16 Penywern-road, S.W.
1886. *LODGE, ALFRED, M.A. The Croft, Peperharow-road, Godalming.
1875. *LODGE, Sir OLIVER J., D.Sc., LL.D., F.R.S. (Pres. A, 1891; Council, 1891–97, 1899–1903), Principal of the University of Birmingham.
1894. *Lodge, Oliver W. F. 225 Hagley-road, Birmingham.
1889. ‡Logan, William. Langley Park, Durham.
1896. §LOMAS, J., F.G.S. 13 Moss-grove, Birkenhead.
1899. §Loncq, Emile. 6 Rue de la Plaine, Laon, Aisne, France.
1902. ‡LONDONDERRY, The Marquess of, K.G., H.M. Lieutenant of the City of Belfast. Londonderry House, Park-lane, W.
1903. ‡Long, Frederick. The Close, Norwich.
1876. ‡Long, H. A. Brisbane, Queensland.
1905. §Long, W. F. City Engineer's Office, Cape Town.
1883. *Long, William. Thelwall Heys, near Warrington.
1883. ‡Long, Mrs. Thelwall Heys, near Warrington.
1883. ‡Long, Miss. Thelwall Heys, near Warrington.
1904. *Longden, J. A., M.Inst.C.E. Stanton-by-Dale, Nottingham.
1905. §Longden, Mrs. J. B. Stanton-by-Dale, Nottingham.
1866. ‡Longdon, Frederick. Osmaston-road, Derby.
1901. ‡Longe, Francis D. The Alders, Marina, Lowestoft.
1898. *Longfield, Miss Gertrude. High Halstow Rectory, Rochester.
1901. *Longstaff, Frederick V., F.R.G.S. Ridgelands, Wimbledon, Surrey.
1875. *Longstaff, George Blundell, M.A., M.D., F.C.S., F.S.S. Highlands, Putney Heath, S.W.
1872. *Longstaff, Llewellyn Wood, F.R.G.S. Ridgelands, Wimbledon, Surrey.
1881. *Longstaff, Mrs. Ll. W. Ridgelands, Wimbledon, Surrey.
1899. *Longstaff, Tom G., B.A., F.R.Met.Soc. Ridgelands, Wimbledon, Surrey.

Year of Election.

1883. *Longton, E. J., M.D. Brown House, Blawith, *viâ* Ulverston.
1894. ‡Lord, Edwin C. E., Ph.D. 247 Washington-street, Brooklyn, U.S.A.
1889. ‡Lord, Sir Riley. 75 Pilgrim-street, Newcastle-upon-Tyne.
1903. ‡Loton, John, M.A. 23 Hawkshead-street, Southport.
1897. ‡Loudon, James, LL.D., President of the University of Toronto, Canada.
1883. *Louis, D. A., F.C.S. 77 Shirland-gardens, W.
1896. §Louis, Henry, M.A., Professor of Mining in the Durham College of Science, Newcastle-on-Tyne.
1887. *Love, A. E. H., M.A., D.Sc., F.R.S., Professor of Natural Philosophy in the University of Oxford. 34 St. Margaret's-road, Oxford.
1886. *Love, E. F. J., M.A. The University, Melbourne, Australia.
1904. *Love, J. B. Outlands, Devonport.
1876. *Love, James, F.R.A.S., F.G.S., F.Z.S. 33 Clanricarde-gardens, W.
1883. ‡Love, James Allen. 8 Eastbourne-road West, Southport.
1905. §Loveday, Professor T. South African College, Cape Town.
1875. *Lovett, W. Jesse. Panton House, Panton-road, Hoole, Chester.
1885. §Lowdell, Sydney Poole. Baldwin's Hill, East Grinstead, Sussex.
1891. §Lowdon, John. St. Hilda's, Barry, Glamorgan.
1885. *Lowe, Arthur C. W. Gosfield Hall, Halstead, Essex.
1892. ‡Lowe, D. T. Heriot's Hospital, Edinburgh.
1905. §Lowe, E. C. Chamber of Trade, Johannesburg.
1886. *Lowe, John Landor, B.Sc., M.Inst.C.E. Spondon, Derbyshire.
1894. ‡Lowenthal, Miss Nellie. 60 New North-road, Huddersfield.
1903. *Lowry, Dr. T. Martin. 44 Blenheim-crescent, W.
1881. ‡Lubbock, Arthur Rolfe. High Elms, Farnborough, R.S.O., Kent.
1881. ‡Lubbock, John B. 14 Berkeley-street, W.
1870. ‡Lubbock, Montague, M.D. 19 Grosvenor-street, W.
1889. ‡Lucas, John. 1 Carlton-terrace, Low Fell, Gateshead.
1901. *Lucas, Keith. Greenhall, Forest Row, Sussex.
1878. ‡Lucas, Joseph. Tooting Graveney, S.W.
1889. ‡*Luckley, George. The Grove, Jesmond, Newcastle-upon-Tyne.*
1891. *Lucovich, Count A. Tyn-y-parc, Whitchurch, near Cardiff.
1881. ‡Luden, C. M. 4 Bootham-terrace, York.
1866. *Lund, Charles. Ilkley, Yorkshire.
1873. ‡Lund, Joseph. Ilkley, Yorkshire.
1850. *Lundie, Cornelius. 32 Newport-road, Cardiff.
1892. ‡Lunn, Robert. Geological Survey Office, Sheriff Court-buildings, Edinburgh.
1853. ‡Lunn, William Joseph, M.D. 23 Charlotte-street, Hull.
1905. §Lunnon, F. J. P.O. Box 400, Pretoria.
1883. *Lupton, Arnold, M.Inst.C.E., F.G.S. 6 De Grey-road, Leeds.
1874. *Lupton, Sydney, M.A. (Local Sec. 1890.) 102 Park-street, Grosvenor-square, W.
1900. ‡Lupton, William C. Bradford.
1864. *Lutley, John. Brockhampton Park, Worcester.
1898. §Luxmoore, Dr. C. M. University College, Reading.
1903. §Lyddon, Ernest H. Lisvane, near Cardiff.
1871. ‡Lyell, Sir Leonard, Bart., F.G.S. 48 Eaton-place, S.W.
1899. ‡Lyle, Professor Thomas R. The University, Melbourne.
1884. ‡Lyman, A. Clarence. 84 Victoria-street, Montreal, Canada.
1884. ‡Lyman, H. H. 74 McTavish-street, Montreal, Canada.
1874. ‡Lynam, James. Ballinasloe, Ireland.
1885. ‡Lyon, Alexander, jun. 52 Carden-place, Aberdeen.
1896. ‡Lyster, A. G. Dockyard, Coburg Dock, Liverpool.
1862. *Lyte, F. Maxwell, M.A., F.C.S. 17 Mentone-mansions, Fulham-road, S.W.

Year of Election.

1905. §Maberly, Dr. John. Shirley House, Woodstock, Cape Colony.
1868. ‡MACALISTER, ALEXANDER, M.A., M.D., F.R.S. (Pres. H, 1892; Council, 1901–), Professor of Anatomy in the University of Cambridge. Torrisdale, Cambridge.
1878. ‡MACALISTER, DONALD, M.A., M.D., B.Sc. St. John's College, Cambridge.
1904. ‡Macalister, Miss M. A. M. Torrisdale, Cambridge.
1897. ‡McAllister, Samuel. 99 Wilcox-street, Toronto, Canada.
1896. §MACALLUM, Professor A. B., Ph.D. (Local Sec. 1897.) 59 St. George-street, Toronto, Canada.
1879. §MacAndrew, James J., F.L.S. Lukesland, Ivybridge, South Devon.
1883. ‡MacAndrew, Mrs. J. J. Lukesland, Ivybridge, South Devon.
1883. §MacAndrew, William. Westwood House, near Colchester.
1866. *M'Arthur, Alexander. 79 Holland-park, W.
1896. ‡McArthur, Charles. Villa Marina, New Brighton, Cheshire.
1896. *Macaulay, F. S., M.A. 19 Dewhurst-road, W.
1904. *Macaulay, W. H. King's College, Cambridge.
1896. ‡MACBRIDE, Professor E. W., M.A., F.R.S. McGill University, Montreal, Canada.
1884. ‡McCabe, T., Chief Examiner of Patents. Patent Office, Ottawa, Canada.
1902. *Maccall, W. T., M.Sc. 223 Burrage-road, Plumstead.
1886. ‡MacCarthy, Rev. E. F. M., M.A. 93 Hagley-road, Birmingham.
1884. *McCarthy, J. J., M.D. 83 Wellington-road, Dublin.
1887. *McCarthy, James. Care of Sir Sherston Baker, Bart., 18 Cavendish-road, Regent's Park, N.W.
1904. §McClean, Frank Kennedy. Rusthall House, Tunbridge Wells.
1876. *M'CLELLAND, A. S. 4 Crown-gardens, Dowanhill, Glasgow.
1902. ‡McClelland, J. A., M.A., Professor of Physics in University College, Dublin.
1868. ‡M'CLINTOCK, Admiral Sir FRANCIS L., R.N., K.C.B., F.R.S., F.R.G.S. United Service Club, Pall Mall, S.W.
1878. *M'Comas, Henry. Pembroke House, Pembroke-road, Dublin.
1901. *MacConkey, Alfred. Queensberry Lodge, Elstree, Herts.
1905. §McConnell, D. E. Montrose-avenue, Orangezicht, Cape Town.
1901. ‡MacCormac, J. M., M.D. 31 Victoria-place, Belfast.
1892. *McCowan, John, M.A., D.Sc. Henderson-street, Bridge of Allan, N.B.
1892. ‡McCrae, George. 3 Dick-place, Edinburgh.
1901. ‡McCrae, John, Ph.D. 7 Kirklee-gardens, Glasgow.
1905. §McCulloch, Principal J. D. Free College, Edinburgh.
1904. ‡McCulloch, Major T., R.A. 68 Victoria-street, S.W.
1899. ‡*McDiarmid, Jabez. The Elms, Stanmore, Middlesex.*
1904. §Macdonald, H. M., M.A., F.R.S., Professor of Mathematics in the University of Aberdeen.
1905. §McDonald, J. G. P.O. Box 67, Bulawayo.
1900. ‡MacDonald, J. R. 3 Lincoln's Inn-fields, W.C.
1890. *MacDonald, Mrs. J. R. 3 Lincoln's Inn-fields, W.C.
1905. §Macdonald, J. S., B.A, Professor of Physiology in the University of Sheffield.
1886. ‡McDonald, John Allen. Hillsboro' House, Derby.
1884. ‡MacDonald, Kenneth. Town Hall, Inverness.
1884. *McDonald, Sir W. C. 891 Sherbrooke-street, Montreal, Canada.
1884. ‡MacDonnell, Mrs. F. H. 1433 St. Catherine-street, Montreal, Canada.
1897. ‡McEwen, William C. 9 South Charlotte-street, Edinburgh.

Year of Election.

1902. ‡Macfadyen, Allan, M.D., B.Sc. Lister Institute of Preventive Medicine, Chelsea-gardens, S.W.
1881. ‡Macfarlane, Alexander, D.Sc., F.R.S.E., Professor of Physics in the University of Texas. Austin, Texas, U.S.A.
1885. ‡Macfarlane, J. M., D.Sc., F.R.S.E., Professor of Biology in the University of Pennsylvania, Lansdowne, Delaware Co., Pennsylvania, U.S.A.
1897. ‡McFarlane, Murray, M.D. 32 Carlton-street, Toronto, Canada.
1905. §Macfarlane, T. J. M. P.O. Box 1198, Johannesburg.
1879. ‡Macfarlane, Walter, jun. 12 Lynedoch-crescent, Glasgow.
1901. ‡Macfee, John. Marguerite, Blackhall, Paisley.
1897. ‡McGaw, Thomas. Queen's Hotel, Toronto, Canada.
1888. ‡MacGeorge, James. 7 Stonor-road, Kensington, W.
1884. ‡MacGillivray, James. 42 Cathcart-street, Montreal, Canada.
1884. ‡MacGoun, Archibald, jun., B.A., B.C.L. Dunavon, Westmount, Montreal, Canada.
1884. *MacGregor, James Gordon, M.A., D.Sc., F.R.S., F.R.S.E., Professor of Natural Philosophy in the University of Edinburgh.
1885. ‡M'Gregor-Robertson, J., M.A., M.B. 26 Buckingham-terrace, Glasgow.
1902. ‡McIlroy, Archibald. Glenvale, Drumbo, Lisburn, Ireland.
1867. *McIntosh W. C., M.D., LL.D., F.R.S., F.R.S.E., F.L.S. (Pres. D, 1885), Professor of Natural History in the University of St. Andrews. 2 Abbotsford-crescent, St. Andrews, N.B.
1883. ‡Mack, Isaac A. Trinity-road, Bootle.
1884. §MacKay, A. H., B.Sc., LL.D., Superintendent of Education. Education Office, Halifax, Nova Scotia, Canada.
1885. ‡Mackay, John Yule, M.D., LL.D., Principal of and Professor of Anatomy in University College, Dundee.
1897. ‡McKay, T. W. G., M.D. Oshawa, Ontario, Canada.
1896. **McKechnie, Duncan. Eccleston Grange, Prescot.*
1873. ‡McKendrick, John G., M.D., LL.D., F.R.S., F.R.S.E. (Pres. I, 1901; Council, 1903-), Professor of Physiology in the University of Glasgow. 2 Buckingham-terrace, Glasgow.
1905. §McKenzie, A. R. P.O. Box 214, Cape Town.
1905. §Mackenzie, Hector. Standard Bank of South Africa, Cape Town.
1905. §Mackenzie, J. 13 Derwent-road, Kloof-road, Cape Town.
1897. ‡McKenzie, John J. 61 Madison-avenue, Toronto, Canada.
1884. ‡MacKenzie, Stephen, M.D. 18 Cavendish-square, W.
1884. ‡McKenzie, Thomas, B.A. School of Science, Toronto, Canada.
1901. *Mackenzie, Thomas Brown. Elenslee, Motherwell.
1883. ‡Mackeson, Henry. Hythe, Kent.
1872. *Mackey, J. A. United University Club, Pall Mall East, S.W.
1867. ‡Mackie, Samuel Joseph. 17 Howley-place, W.
1901. §Mackie, William, M.D. 13 North-street, Elgin.
1887. ‡Mackinder, H. J., M.A., F.R.G.S. (Pres. E, 1895; Council, 1904-1905.) London School of Economics, Clare Market, W.C.
1905. §Macindoe, Flowerdue. 23 Saratoga-avenue, Johannesburg.
1891. ‡Mackintosh, A. C. 88 Plymouth-road, Penarth.
1892. ‡Maclagan, Philip R. D. St. Catherine's, Liberton, Midlothian.
1892. ‡Maclagan, R. Craig, M.D., F.R.S.E. 5 Coates-crescent, Edinburgh.
1885. *M'Laren, The Hon. Lord, F.R.S.E., F.R.A.S. 46 Moray-place Edinburgh.
1894. *McLaren, Mrs. E. L. Colby, M.B., Ch.B. 11 Leopold-place, Edinburgh.
1897. ‡MacLaren, J. F. 380 Victoria-street, Toronto, Canada.

Year of Election.

1901. ‡Maclaren, J. Malcolm. 62 Sydney-street, South Kensington, S.W.
1905. §McLaren, Thomas. P.O. Box 1034, Johannesburg.
1873. ‡MacLaren, Walter S. B. Newington House, Edinburgh.
1897. ‡MacLaren, Rev. Wm., D.D. 57 St. George-street, Toronto, Canada.
1901. ‡Maclay, James. 3 Woodlands-terrace, Glasgow.
1901. ‡Maclay, William. Thornwood, Langside, Glasgow.
1901. §McLean, Angus, B.Sc. Ascog, Meikleriggs, Paisley.
1905. §MacLean, Lachlan. Greenhill, Kenilworth, Cape Colony.
1892. *MACLEAN, MAGNUS, M.A., D.Sc., F.R.S.E. (Local Sec. 1901), Professor of Electrical Engineering, Technical College, Glasgow.
1905. *Maclear, Admiral J. P. Beaconscroft, Chiddingfold, Godalming.
1884. ‡McLennan, Frank. 317 Drummond-street, Montreal, Canada.
1884. ‡McLennan, Hugh. 317 Drummond-street, Montreal, Canada.
1884. ‡McLennan, John. Lancaster, Ontario, Canada.
1868. §McLEOD, HERBERT, F.R.S. (Pres. B, 1892; Council, 1885-90). 9 Coverdale, Richmond, Surrey.
1892. ‡Macleod, W. Bowman. 16 George-square, Edinburgh.
1883. ‡MACMAHON, Major PERCY A., R.A., D.Sc., F.R.S. (GENERAL SECRETARY, 1902- ; Pres. A, 1901; Council, 1898-1902.) Queen Anne's-mansions, Westminster, S.W.
1902. ‡McMordie, Robert J. Cabin Hill, Knock, Co. Down.
1884. ‡McMurrick, J. Playfair. University of Michigan, Ann Arbor, Michigan, U.S.A.
1905. §MacNay, Arthur. Cape Government Railway Offices, De Aar, Cape Colony.
1867. ‡M'Neill, John. Balhousie House, Perth.
1878. ‡Macnie, George. 59 Bolton-street, Dublin.
1887. ‡Maconochie, A. W. Care of Messrs. Maconochie Bros., Lowestoft.
1905. §Macphail, Dr. S. Rutherford. Rowditch, Derby.
1883. ‡Macpherson, J. 44 Frederick-street, Edinburgh.
1905. §Macrae, Harold J. P.O. Box 817, Johannesburg.
1902. ‡McWeeney, E. J., M.D. 84 Stephen's-green, Dublin.
1902. §McWhirter, William. 9 Walworth-terrace, Glasgow.
1887. ‡Macy, Jesse. Grinnell, Iowa, U.S.A.
1883. ‡Madden, W. H. Marlborough College, Wilts.
1905. §Magenis, Lady Louisa. 34 Lennox-gardens, S.W.
1902. ‡Magill, R., M.A., Ph.D. The Manse, Maghera, Co. Derry.
1868. ‡Magnay, F. A. Drayton, near Norwich.
1875. *MAGNUS, Sir PHILIP, B.Sc. 16 Gloucester-terrace, Hyde Park, W.
1896. ‡Maguire, Thomas Philip. Eastfield, Lodge-lane, Liverpool.
1902. ‡Mahon, J. L. 2 May-street, Drumcondra, Dublin.
1878. ‡Mahony, W. A. 34 College-green, Dublin.
1902. ‡Maitland, Miss Agnes C. Somerville College, Oxford.
1899. ‡Makarius, Saleem. 'Al Mokattam,' Cairo.
1905. §Maltby, Lieutenant G. R., R.N. 54 St. George's-square, S.W.
1857. ‡MALLET, JOHN WILLIAM, Ph.D., M.D., F.R.S., F.C.S., Professor of Chemistry in the University of Virginia, Albemarle Co., U.S.A.
1896. *Manbré, Alexandre. 15 Alexandra-drive, Liverpool.
1897. ‡MANCE, Sir H. C. 32 Earl's Court-square, S.W.
1887. ‡MANCHESTER, The Right Rev. the Lord Bishop of, D.D. Bishop's Court, Manchester.
1903. ‡Manifold, C. C. 16 St. James's-square, S.W.
1901. ‡Mann, John, jun., M.A. 137 West George-street, Glasgow.
1888. ‡Mann, W. J. Rodney House, Trowbridge.
1905. §Manning, D. W., F.R.G.S. Roydon, Rosebank, Cape Town

Year of Election.

1894. ‡Manning, Percy, M.A., F.S.A. Watford, Herts.
1905. §Mansfield, J. D. 94 St. George's-street, Cape Town.
1891. ‡Manuel, James. 175 Newport-road, Cardiff.
1887. *March, Henry Colley, M.D., F.S.A. Portesham, Dorchester, Dorsetshire.
1902. *Marchant, Dr. E. W. University College, Liverpool.
1870. ‡Marcoartu, His Excellency Don Arturo de. Madrid.
1898. *Mardon, Heber. 2 Litfield-place, Clifton, Bristol.
1900. ‡Margerison, Samuel. Calverley Lodge, near Leeds.
1883. ‡Marginson, James Fleetwood. The Mount, Fleetwood, Lancashire.
1887. ‡*Markham, Christopher A., F.R.Met.Soc. Spratton, Northampton.*
1864. ‡Markham, Sir Clements R., K.C.B., F.R.S., Pres.R.G.S., F.S.A. (Pres. E, 1879; Council 1893–96). 21 Eccleston-square, S.W.
1905. §Marks, Samuel. P.O. Box 379, Pretoria.
1863. ‡Marley, John. Mining Office, Darlington.
1888. ‡Marling, W. J. Stanley Park, Stroud, Gloucestershire.
1888. ‡Marling, Lady. Stanley Park, Stroud, Gloucestershire.
1905. §Marloth, R., M.A., Ph.D. P. O. Box 359, Cape Town.
1881. *Marr, J. E., M.A., D.Sc., F.R.S., F.G.S. (Pres. C, 1896; Council 1896–1902). St. John's College, Cambridge.
1903. §Marriott, William. Royal Meteorological Society, 70 Victoria-street, S.W.
1887. ‡*Marsden, Benjamin. Westleigh, Heaton Mersey, Manchester.*
1884. *Marsden, Samuel. 1015 North Leffingwell-avenue, St. Louis, Missouri, U.S.A.
1892. *Marsden-Smedley, J. B. Lea Green, Cromford, Derbyshire.
1883. *Marsh, Henry. 72 Wellington-street, Leeds.
1887. ‡Marsh, J. E., M.A. The Museum, Oxford.
1864. ‡Marsh, Thomas Edward Miller. 37 Grosvenor-place, Bath.
1889. *Marshall, Alfred, M.A., LL.D., D.Sc. (Pres. F, 1890), Professor of Political Economy in the University of Cambridge. Balliol Croft, Madingley-road, Cambridge.
1904. ‡Marshall, F. H. A. University of Edinburgh.
1905. §Marshall, G. A. P.O. Box 149, Salisbury, Cape Colony.
1892. §Marshall, Hugh, D.Sc., F.R.S., F.R.S.E. 12 Lonsdale-terrace, Edinburgh.
1890. ‡Marshall, John. Derwent Island, Keswick.
1901. §Marshall, Robert. 97 Wellington-street, Glasgow.
1886. *Marshall, William Bayley, M.Inst.C.E. Richmond Hill, Edgbaston, Birmingham.
1849. *Marshall, William P., M.Inst.C.E. Richmond Hill, Edgbaston, Birmingham.
1865. ‡Marten, Edward Bindon. Pedmore, near Stourbridge.
1899. ‡Martin, Miss A. M. Park View, 32 Bayham-road, Sevenoaks.
1891. *Martin, Edward P., J.P. The Hill, Abergavenny, Monmouthshire.
1905. §Martin, John. P.O. Box 217, Germiston, Transvaal.
1884. §Martin, N. H., J.P., F.R.S.E., F.L.S. Ravenswood, Low Fell, Gateshead.
1889. *Martin, Thomas Henry, Assoc.M.Inst.C.E. Northdene, New Barnet, Herts.
1865. ‡Martineau, R. F. 18 Highfield-road, Edgbaston, Birmingham.
1883. ‡Marwick, Sir J. D., LL.D., F.R.S.E. (Local Sec. 1871, 1876, 1901.) Glasgow.
1905. §Marwick, J. S. P.O. Box 1166, Johannesburg.
1905. §Marx, Mrs. Charles. Shabana, Robinson-street, Belgravia, South Africa.
1891. ‡Marychurch, J. G. 46 Park-street, Cardiff.

Year of Election.

1873. *Masham, Lord. Swinton Park, Swinton.
1847. ‡Maskelyne, Nevil Story, M.A., D.Sc., F.R.S., F.G.S. (Council 1874–80). Basset Down House, Swindon.
1905. *Mason, Justice A. W. Supreme Court, Pretoria.
1886. ‡Mason, Hon. J. E. Fiji.
1893. *Mason, Thomas. Endersleigh, Alexandra Park, Nottingham.
1891. *Massey, William H., M.Inst.C.E. Twyford, R.S.O., Berkshire.
1885. ‡Masson, Orme, D.Sc., F.R.S., Professor of Chemistry in the University of Melbourne, Victoria, Australia.
1905. §Massy, Miss M. York House, Teignmouth, Devon.
1898. ‡Masterman, A. T. University of St. Andrews, N.B.
1901. *Mather, G. R. Boxlea, Wellingborough.
1883. ‡Mather, Robert V. Birkdale Lodge, Birkdale, Southport.
1887. *Mather, Sir William, M.Inst.C.E. Salford Iron Works, Manchester.
1905. §Mathew, Alfred Harfield. P.O. Box 242, Cape Town.
1865. ‡Mathews, C. E. Waterloo-street, Birmingham.
1898 ‡Mathews, E. R. Norris. Cotham-road, Cotham, Bristol.
1894. ‡Mathews, G. B., M.A., F.R.S. St. John's College, Cambridge.
1889. ‡Mathews, John Hitchcock. 1 Queen's-gardens, Hyde Park, W.
1881. ‡Mathwin, Henry, B.A. 26 Oxford-road, Birkdale, Southport.
1883. ‡Mathwin, Mrs. H. 26 Oxford-road, Birkdale, Southport.
1902. ‡Matley, C. A. 90 St. Lawrence-road, Clontarf, Dublin.
1904. *Matthaei, Miss G. L. C. Newnham College, Cambridge.
1904. §Matthews, D. J. The Laboratory, Citadel Hill, Plymouth.
1858. ‡Matthews, F. C. Mandre Works, Driffield, Yorkshire.
1905. §Matthews, J. Wright, M.D. P.O. Box 437, Johannesburg.
1899. ‡Matthews, William, C.M.G., M.Inst.C.E. 9 Victoria-street, S.W.
1893. ‡Mavor, Professor James. University of Toronto, Canada.
1865. *Maw, George, F.L.S., F.G.S., F.S.A. Benthall, Kenley, Surrey.
1894. §Maxim, Sir Hiram S. 18 Queen's Gate-place, Kensington, S.W.
1903. ‡Maxwell, J. M. 37 Ash-street, Southport.
1901. *May, W. Page, M.D., B.Sc. 9 Manchester-square, W.
1884. *Maybury, A. C., D.Sc. 8 Heathcote-street, W.C.
1905. §Maylard, A. Ernest. 10 Blythswood-square, Glasgow.
1905. §Maylard, Mrs. 10 Blythswood-square, Glasgow.
1878. *Mayne, Thomas. 33 Castle-street, Dublin.
1904. ‡Mayo, Rev. J., LL.D. 6 Warkworth-terrace, Cambridge.
1905. §Mearns, J. Herbert, M.D. Edenville, 10 Oxford-road, Observatory, Cape Town.
1871. ‡Meikle, James, F.S.S. 6 St. Andrew's-square, Edinburgh.
1879. §Meiklejohn, John W. S., M.D. 105 Holland-road, W.
1905. §Mein, W. W. P.O. Box 1024, Johannesburg.
1881. *Meldola, Raphael, F.R.S., F.R.A.S., F.C.S., F.I C. (Pres. B, 1895; Council 1892–99), Professor of Chemistry in the Finsbury Technical College, City and Guilds of London Institute. 6 Brunswick-square, W.C.
1883. ‡Mellis, Rev. James. 23 Part-street, Southport.
1879. *Mellish, Henry. Hodsock Priory, Worksop.
1866. ‡Mello, Rev. J. M., M.A., F.G.S. Cliff Hill, Warwick.
1883. ‡Mello, Mrs. J. M. Cliff Hill, Warwick.
1896. §Mellor, G. H. Weston, Blundellsands, Liverpool.
1881. §Melrose, James. Clifton Croft, York.
1905. *Melvill, E. H. V., F.G.S., F.R.G.S. P.O. Box 719, Johannesburg.
1887. ‡Melvill, J. Cosmo, M.A. Kersal Cottage, Prestwich, Manchester.
1863. ‡Melvin, Alexander. 42 Buccleuch-place, Edinburgh.
1901. ‡Mennell, F. P. 8 Addison-road, W.

Year of Election.

1862. ‡MENNELL, HENRY T. St. Dunstan's-buildings, Great Tower-street, E.C.
1905. §Meredith, H. O. Dunwood House, Withington, Manchester.
1879. ‡MERIVALE, JOHN HERMAN, M.A. (Local Sec. 1889). Togston Hall, Acklington.
1899. *Merrett, William H., F.I.C. Hatherley, Grosvenor-road, Wallington, Surrey.
1905. §Merriman, Hon. John X. Shoongezicht, Stellenbosch, Cape Colony.
1899. ‡Merryweather, J. C. 4 Whitehall-court, S.W.
1889. *Merz, John Theodore. The Quarries, Newcastle-upon-Tyne.
1863. ‡Messent, P. T. 4 Northumberland-terrace, Tynemouth.
1905. §Methven, Cathcart W. Club Arcade, Smith-street, Durban.
1896. ‡Metzler, W. H., Professor of Mathematics in Syracuse University, Syracuse, New York, U.S.A.
1869. ‡MIALL, LOUIS C., F.R.S., F.L.S., F.G.S. (Pres. D, 1897; Local Sec. 1890), Professor of Biology in the University of Leeds. Richmond-mount, Headingley, Leeds.
1903. ‡Micklethwait, Miss F. G. Queen's College, Galway.
1865. ‡Middlemore, William. Edgbaston, Birmingham.
1881. *Middlesbrough, The Right Rev. Richard Lacy, D.D., Bishop of Middlesbrough.
1893. ‡Middleton, A. 25 Lister-gate, Nottingham.
1881. ‡Middleton, R. Morton, F.L.S., F.Z.S. 46 Windsor-road, Ealing, W.
1904. ‡Middleton, T. H., M.A., Professor of Agriculture in the University of Cambridge. South House, Barton-road, Cambridge.
1894. *MIERS, H. A., M.A., F.R.S., F.G.S. (Pres. C, 1905), Professor of Mineralogy in the University of Oxford. Magdalen College, Oxford.
1889. ‡Milburn, Sir John D., Bart. Queen-street, Newcastle-upon-Tyne.
1886. ‡Miles, Charles Albert. Buenos Ayres.
1881. ‡*MILES, MORRIS (Local Sec. 1882). Warbourne, Hill-lane, Southampton.*
1885. §MILL, HUGH ROBERT, D.Sc., LL.D., F.R.S.E., F.R.G.S. (Pres. E, 1901.) 62 Camden-square, N.W.
1905. §Mill, Mrs. H. R. 62 Camden-square, N.W.
1889. *Millar, Robert Cockburn. 30 York-place, Edinburgh.
Millar, Thomas, M.A., LL.D., F.R.S.E. Perth.
1895. ‡Miller, Henry, M.Inst.C.E. Bosmere House, Norwich-road, Ipswich.
1888. ‡Miller, J. Bruce. Rubislaw Den North, Aberdeen.
1885. ‡Miller, John. 9 Rubislaw-terrace, Aberdeen.
1886. ‡*Miller, Rev. John, B.D. The College, Weymouth.*
1884. ‡Miller, T. F., B.Ap.Sc. Napanee, Ontario, Canada.
1895. ‡Miller, Thomas, M.Inst.C.E. 9 Thoroughfare, Ipswich.
1876. ‡Miller, Thomas Paterson. Cairns, Cambuslang, N.B.
1897. ‡Miller, Willet G., Professor of Geology in Queen's University, Kingston, Ontario, Canada.
1902. ‡Millin, S. T. Sheridan Lodge, Helen's Bay, Co. Down.
1904. ‡Millis, C. T. Hollydene, Wimbledon Park-road, Wimbledon.
1905. §Mills, Mrs. A. A. Bellevue East, South Africa.
1868. *MILLS, EDMUND J., D.Sc., F.R.S., F.C.S. 64 Twyford-avenue, West Acton, W.
1880. ‡Mills, Mansfeldt H., M.Inst.C.E., F.G.S. Sherwood Hall, Mansfield.
1902. ‡Mills, W. Sloan, M.A. Vine Cottage, Donaghmore, Newry.
1885. ‡Milne, Alexander D. 40 Albyn-place, Aberdeen.
1882. *MILNE, JOHN, F.R.S., F.G.S. Shide Hill House, Shide, Isle of Wight.

Year of Election.

1903. *Milne, R. M. Royal Military Academy, Woolwich.
1885. ‡Milne, William. 40 Albyn-place, Aberdeen.
1898. *Milner, S. Roslington, D.Sc. University College, Sheffield.
1882. ‡Milnes, Alfred, M.A., F.S.S. 22A Goldhurst-terrace, South Hampstead, N.W.
1880. ‡MINCHIN, G. M., M.A., F.R.S., Professor of Mathematics in the Royal Indian Engineering College, Cooper's Hill, Surrey.
1859. ‡Mitchell, Alexander, M.D. Old Rain, Aberdeen.
1901. *Mitchell, Andrew Acworth. 7 Huntly-gardens, Glasgow.
1883. ‡Mitchell, Charles T., M.A. 41 Addison-gardens North, Kensington, W.
1883. ‡Mitchell, Mrs. Charles T. 41 Addison-gardens North, Kensington, W.
1901. *Mitchell, G. A. 5 West Regent-street, Glasgow.
1905. §Mitchell, John. Government School House, Jeppestown, Transvaal.
1885. ‡Mitchell, P. Chalmers, M.A., D.Sc., Sec.Z.S. 3 Hanover-square, W.
1905. *Mitchell, William Edward. Ferreira Deep, Johannesburg.
1905. §Mitter, M. Care of J. Speak, Esq., The Grange, Kirton, near Boston.
1895. *Moat, William, M.A. Johnson Hall, Eccleshall, Staffordshire.
1885. ‡Moffat, William. 7 Queen's-gardens, Aberdeen.
1905. §Moir, James, D.Sc. Mines Department, Johannesburg.
1905. §Moir, Dr. W. Ironside. Care of Dr. McAulay, Cleveland, Transvaal.
1905. §Molengraaff, Dr. P.O. Box 149, Johannesburg.
1883. ‡Mollison, W. L., M.A. Clare College, Cambridge.
1877. *Molloy, Right Rev. Gerald, D.D. 86 Stephen's-green, Dublin.
1884. ‡Monaghan, Patrick. Halifax (Box 317), Nova Scotia, Canada.
1900. *MONCKTON, H. W., Treas.L.S., F.G.S. 3 Harcourt-buildings, Temple, E.C.
1905. §MONCRIEFF, Colonel Sir C. SCOTT, G.C.S.I., K.C.M.G., R.E. (Pres. G. 1905.) 11 Cheyne-walk, S.W.
1905. §Moncrieff, Lady Scott. 11 Cheyne-walk, S.W.
1887. *MOND, LUDWIG, Ph.D., D.Sc., F.R.S., F.C.S. (Pres. B, 1896.) 20 Avenue-road, Regent's Park, N.W.
1891. *Mond, Robert Ludwig, M.A., F.R.S.E., F.G.S. 20 Avenue-road, Regent's Park, N.W.
1882. *Montagu, Sir Samuel, Bart., M.P. 12 Kensington Palace-gardens, W.
1892. ‡Montgomery, Very Rev. J. F. 17 Athole-crescent, Edinburgh.
1872. ‡Montgomery, R. Mortimer. 3 Porchester-place, Edgware-road, W.
1872. ‡Moon, W., LL.D. 104 Queen's-road, Brighton.
1896. ‡Moore, A. W., M.A. Woodbourne House, Douglas, Isle of Man.
1905. *Moore, Brian. Thornhill Villa, Marsh, Huddersfield.
1905. §Moore, Charles Elliott. P.O. Box 5382, Johannesburg.
1894. §Moore, Harold E. Oaklands, The Avenue, Beckenham, Kent.
1890. ‡Moore, Major, R.E. School of Military Engineering, Chatham.
1901. *Moore, Robert T. 142 St. Vincent-street, Glasgow.
1905. §Moore, T. H. Thornhill Villa, Marsh, Huddersfield.
1896. *Mordey, W. M. 82 Victoria-street, S.W.
1905. §More, T. E. Padern. Carlton-buildings, Parliament-street, Cape Town.
1891. ‡Morel, P. Lavernock House, near Cardiff.
1901. *Moreno, Francisco P. La Plata Museum, Argentina.
1881. ‡MORGAN, ALFRED. 50 West Bay-street, Jacksonville, Florida, U.S.A.
1905. *Morgan, Miss Annie. Friedrichstrasse No. 2, Vienna.
1895. ‡MORGAN, C. LLOYD, F.R.S., F.G.S., Principal of University College, Bristol. 16 Canynge-road, Clifton, Bristol.
1873. ‡Morgan, Edward Delmar, F.R.G.S. 15 Roland-gardens, South Kensington, S.W.

Year of Election.

1891. ‡Morgan, F. Forest Lodge, Ruspidge, Gloucestershire.
1896. §Morgan, George. 21 Upper Parliament-street, Liverpool.
1902. ‡MORGAN, GILBERT T., D.Sc., F.I.C. Royal College of Science, S.W.
1887. ‡Morgan, John Gray. 38 Lloyd-street, Manchester.
1902. *Morgan, Septimus Vaughan. 37 Harrington-gardens, S.W.
1882. ‡Morgan, Thomas, J.P. Cross House, Southampton.
1901. *Morison, James. Perth.
1892. ‡Morison, John, M.D., F.G.S. Victoria-street, St. Albans.
1893. ‡Morland, John, J.P. Glastonbury.
1891. ‡Morley, H. The Gas Works, Cardiff.
1883. *MORLEY, HENRY FORSTER, M.A., D.Sc., F.C.S. 5 Lyndhurst-road, Hampstead, N.W.
1889. ‡MORLEY, The Right Hon. JOHN, M.A., LL.D., M.P., F.R.S. Flowermead, Wimbledon Park, Surrey.
1896. ‡Morrell, R. S. Caius College, Cambridge.
1881. ‡Morrell, W. W. York City and County Bank, York.
1883. ‡Morris, C. S. Millbrook Iron Works, Landore, South Wales.
1892. ‡MORRIS, SIR DANIEL, K.C.M.G., M.A., D.Sc., F.L.S. Barbados, West Indies.
1905 §Morris, F., M.B., B.Sc. 18 Hope-street, Cape Town.
1883. ‡Morris, George Lockwood. Millbrook Iron Works, Swansea.
1896. *Morris, J. T. 13 Somers-place, W.
1880. §Morris, James. 6 Windsor-street, Uplands, Swansea.
1874. ‡Morrison, G. James, M.Inst.C.E. 7 The Sanctuary, Westminster, S.W.
1899. §MORROW, Captain JOHN, M.Sc. 19 Elliston-road, Redland, Bristol.
1865. ‡Mortimer, J. R. St. John's-villas, Driffield.
1869. ‡Mortimer, William. Bedford-circus, Exeter.
1886. *Morton, P. F. 15 Ashley-place, Westminster, S.W.
1887. ‡Morton, Percy, M.A. Illtyd House, Brecon, South Wales.
1896. *MORTON, WILLIAM B., M.A., Professor of Natural Philosophy in Queen's College, Belfast.
1878. *Moss, JOHN FRANCIS, F.R.G.S. (Local Sec. 1879.) Beechwood, Brincliffe, Sheffield.
1876. §Moss, RICHARD JACKSON, F.I.C., M.R.I.A. Royal Dublin Society, and St. Aubyn's, Ballybrack, Co. Dublin.
1892. ‡Mossman, R. C., F.R.S.E. 10 Blacket-place, Edinburgh.
1873. ‡Mossman, William. St. Hilda's, Frizinghall, Bradford.
1892. *Mostyn, S. G., M.A., M.B. Health Office, South Shields.
1866. ‡MOTT, FREDERICK T., F.R.G.S. Crescent House, Leicester.
1878. *MOULTON, J. FLETCHER, M.A., K.C., M.P., F.R.S. 57 Onslow-square, S.W.
1863. ‡Mounsey, Edward. Sunderland.
1877. ‡MOUNT-EDGCUMBE, The Right Hon. the Earl of, D.C.L. Mount-Edgcumbe, Devonport.
1899. §Mowll, Martyn. Chaldercot, Leyburne-road, Dover.
1887. ‡Moxon, Thomas B. County Bank, Manchester.
1905. §Moylan, Miss V. C. 3 Canning-place, Palace Gate, W.
1888. ‡Moyle, R. E., M.A., F.C.S. Heightley, Chudleigh, Devon.
1884. ‡Moyse, C. E., B.A., Professor of English Language and Literature in McGill College, Montreal. 802 Sherbrooke-street, Montreal, Canada.
1884. ‡Moyse, Charles E. 802 Sherbrooke-street, Montreal, Canada.
1905. *Moysey, Miss E. L. Pitcroft, Guildford, Surrey.
1899. *Muff, Herbert B. Geological Survey Office, Edinburgh.
1894. ‡*Mugliston, Rev. J., M.A. Newick House, Cheltenham.*

Year of
Election.

1902. §Muir, Arthur H., C.A. 2 Wellington-place, Belfast.
1874. ‡MUIR, M. M. PATTISON, M.A. Gonville and Caius College, Cambridge.
1904. §Muir, William. Rowallan, Newton Stewart, N.B.
1872. *MUIRHEAD, ALEXANDER, D.Sc., F.R.S., F.C.S. 12 Carteret-street, Queen Anne's-gate, Westminster, S.W.
1905. *Muirhead, James M. P. Markham's-chambers, St. George's-street, Cape Town.
1876. *Muirhead, Robert Franklin, M.A., D.Sc. 24 Kersland-street, Hillhead, Glasgow.
1902. ‡Mullan, James. Castlerock, Co. Derry.
1884. *MÜLLER, HUGO, Ph.D., F.R.S., F.C.S. 13 Park-square East, Regent's Park, N.W.
1880. ‡Muller, Hugo M. 1 Grünanger-gasse, Vienna.
1905. §Mulligan, A. 'Natal Mercury' Office, Durban, Natal.
1904. §Mullinger, J. Bass, M.A. St. John's College, Cambridge.
1897. ‡Mullins, W. E. Hampstead, N.W.
1898. ‡Mumford, C. E. Bury St. Edmunds.
1901. *Munby, Alan E. 7 Chalcot-crescent, Primrose Hill, N.W.
Munby, Arthur Joseph. 6 Fig Tree-court, Temple, E.C.
1904. ‡Munro, A. Queen's College, Cambridge.
1901. ‡Munro, Donald, M.D., J.P. Wheatholm, Pollokshaws, Glasgow.
1898. ‡Munro, John, Professor of Mechanical Engineering in the Merchant Venturers' Technical College, Bristol.
1883. *MUNRO, ROBERT, M.A., M.D. (Pres. H, 1893). 48 Manor-place, Edinburgh.
1855. ‡Murdoch, James Barclay. Capelrig, Mearns, Renfrewshire.
1890. ‡Murphy, A. J. Preston House, Leeds.
1889. ‡Murphy, James, M.A., M.D. Holly House, Sunderland.
1884. §Murphy, Patrick. Marcus-square, Newry, Ireland.
1887. ‡Murray, A. Hazeldean, Kersal, Manchester.
1905. §Murray, Charles F. K., M.D. Kenilworth House, Kenilworth, Cape Colony.
1905. §Murray, Dr. F. Londinium, London-road, Sea Point, Cape Town.
1891. ‡MURRAY, G. R. M., F.R.S., F.R.S.E., F.L.S. British Museum (Natural History), South Kensington, S.W.
1905. §Murray, Dr. J. A. H. Sunnyside, Oxford.
1905. §Murray, Mrs. Sunnyside, Oxford.
1884. ‡MURRAY, Sir JOHN, K.C.B., LL.D., D.Sc., Ph.D., F.R.S., F.R.S.E. (Pres. E, 1899.) Challenger Lodge, Wardie, Edinburgh.
1884. ‡Murray, J. Clark, LL.D. 111 McKay-street, Montreal, Canada.
1903. ‡Murray, J. D. Rowbottom-square, Wigan.
1872. ‡Murray, J. Jardine, F.R.C.S.E. 99 Montpellier-road, Brighton.
1892. ‡Murray, T. S. 1 Nelson-street, Dundee.
1863. ‡Murray, William, M.D. 9 Ellison-place, Newcastle-on-Tyne.
1897. ‡Musgrave, James, M.D. 511 Bloor-street West, Toronto, Canada.
1870. *Muspratt, Edward Knowles. Seaforth Hall, near Liverpool.
1902. ‡Myddleton, Alfred. 62 Duncairn-street, Belfast.
1902. *Myers, Charles S., M.A., M.D. 62 Holland-park, W.
1890. *MYRES, JOHN L., M.A., F.S.A. 1 Norham-gardens, Oxford.

1886. ‡NAGEL, D. H., M.A. (Local Sec. 1894.) Trinity College, Oxford.
1892. *Nairn, Sir Michael B., Bart. Kirkcaldy, N.B.
1890. §Nalder, Francis Henry. 34 Queen-street, E.C.
1905. §Napier, Dr. Francis. 73 Jeppe street, Von Brandis-square, Johannesburg.

Year of
Election.

1876. ‡Napier, James S. 9 Woodside-place, Glasgow.
1872. ‡NARES, Admiral Sir G. S., K.C.B., R.N., F.R.S., F.R.G.S. 11 Claremont-road, Surbiton.
1887. ‡Nason, Professor Henry B., Ph.D. Troy, New York, U.S.A.
1896. ‡Neal, James E., U.S. Consul. 26 Chapel-street, Liverpool.
1887. ‡Neild, Charles. 19 Chapel-walks, Manchester.
1883. *Neild, Theodore, B.A. The Vista, Leominster.
1887. ‡*Neill, Robert, jun. Beech Mount, Higher Broughton, Manchester.*
1855. ‡Neilson, Walter. 172 West George-street, Glasgow.
1897. ‡Nesbitt, Beattie S. A., M.D. 71 Grosvenor-street, Toronto, Canada.
1898. §Nevill, Rev. J. H. N., M.A. The Vicarage, Stoke Gabriel, South Devon.
1866. *Nevill, The Right Rev. Samuel Tarratt, D.D., F.L.S., Bishop of Dunedin, New Zealand.
1889. ‡NEVILLE, F. H., M.A., F.R.S. Sidney College, Cambridge.
1889. *Newall, H. Frank, M.A., F.R.S., F.R.A.S. Madingley Rise, Cambridge.
1901. ‡Newbigin, Miss Marion, D.Sc. 1 Greenbank-road, Morningside, Edinburgh.
1886. ‡Newbolt, F. G. Oakley Lodge, Weybridge, Surrey.
1889. ‡Newcastle, Right Rev. A. T. Lloyd, D.D., Bishop of. Benwell Tower, Newcastle-upon-Tyne.
1901. ‡Newman, F. H. Tullie House, Carlisle.
1889. ‡Newstead, A. H. L., B.A. 38 Green-street, Bethnal Green, N.E.
1860. *NEWTON, ALFRED, M.A., F.R.S., F.L.S. (Pres. D, 1887; Council, 1875–82), Professor of Zoology and Comparative Anatomy in the University of Cambridge. Magdalene College, Cambridge.
1892. ‡NEWTON, E. T., F.R.S., F.G.S. Geological Museum, Jermyn-street, S.W.
1867. ‡Nicholl, Thomas. Dundee.
1887. *Nicholson, John Carr, J.P. Moorfield House, Headingley, Leeds.
1884. ‡NICHOLSON, JOSEPH S., M.A., D.Sc. (Pres. F, 1893), Professor of Political Economy in the University of Edinburgh. Eden Lodge, Newbattle-terrace, Edinburgh.
1883. ‡Nicholson, Richard, J.P. Whinfield, Hesketh Park, Southport.
1887. ‡Nicholson, Robert H. Bourchier. 21 Albion-street, Hull.
1893. ‡Nickolls, John B., F.C.S. The Laboratory, Guernsey.
1887. ‡Nickson, William. Shelton, Sibson-road, Sale, Manchester.
1901. ‡NICOL, JAMES, City Chamberlain. Glasgow.
1885. ‡Nicol, W. W. J., D.Sc., F.R.S.E. 15 Blacket-place, Edinburgh.
1896. ‡Nisbet, J. Tawse. 175 Lodge-lane, Liverpool.
1878. ‡NIVEN, CHARLES, M.A., F.R.S., F.R.A.S., Professor of Natural Philosophy in the University of Aberdeen. 6 Chanonry, Old Aberdeen.
1877. ‡Niven, Professor James, M.A. King's College, Aberdeen.
1863. *NOBLE, Sir ANDREW, Bart., K.C.B., D.Sc., F.R.S., F.R.A.S., F.C.S. (Pres. G, 1890; Council, 1903– ; Local Sec. 1863.) Elswick Works, and Jesmond Dene House, Newcastle-upon-Tyne.
1879. ‡Noble, T. S. Lendal, York.
1887. ‡Nodal, John H. The Grange, Heaton Moor, near Stockport.
1905. §Noel, Miss Emilia, F.L.S. Care of Miss Gibbs, 9 South-street, Thurloe-square, S.W.
1863. §NORMAN, Rev. Canon ALFRED MERLE, M.A., D.C.L., LL.D., F.R.S., F.L.S. The Red House, Berkhamsted.
1888. ‡Norman, George. 12 Brock-street, Bath.
1865. ‡NORRIS, RICHARD, M.D. 2 Walsall-road, Birchfield, Birmingham.
1872. ‡Norris, Thomas George. Gorphwysfa, Llanrwst, North Wales.

Year of Election.

1883. *Norris, William G. Dale House, Coalbrookdale, R.S.O., Shropshire.
1894. §NOTCUTT, S. A., LL.M., B.A., B.Sc. (Local Sec. 1895.) Constitution Hill, Ipswich.
1903. ‡Noton, John. 45 Part-street, Southport.
Nowell, John. Farnley Wood, near Huddersfield.
1896. ‡Nugent, the Right Rev. Monsignor. Harewood House, Formby, Lancashire.

1898. *O'Brien, Neville Forth. Queen Anne's-mansions, S.W.
1878. ‡O'Conor Don, The. Clonalis, Castlerea, Ireland.
1883. ‡Odgers, William Blake, M.A., LL.D. 4 Elm-court, Temple, E.C.
1858. *ODLING, WILLIAM, M.B., F.R.S., V.P.C.S. (Pres. B, 1864; Council 1865–70), Waynflete Professor of Chemistry in the University of Oxford. 15 Norham-gardens, Oxford.
1894. ‡Ogden, James. Kilner Deyne, Rochdale.
1902. §Ogden, James Neal. Claremont, Heaton Chapel, Stockport.
1896. ‡*Ogden, Thomas. 4 Prince's-avenue, Liverpool.*
1885. ‡Ogilvie, Alexander, LL.D. Gordon's College, Aberdeen.
1876. ‡Ogilvie, Campbell P. Sizewell House, Leiston, Suffolk.
1885. ‡OGILVIE, F. GRANT, M.A., B.Sc., F.R.S.E. (Local Sec. 1892.) Board of Education, S.W.
1859. ‡Ogilvy, Rev. C. W. Norman. Baldan House, Dundee.
*Ogle, William, M.D., M.A. The Elms, Duffield-road, Derby.
1905. *Oke, Alfred William, B.A., LL.M., F.G.S., F.L.S. 32 Denmark-villas, Hove, Brighton.
1905. §Okell, Samuel. Overley, Langham-road, Bowdon, Cheshire.
1884. ‡O'Halloran, J. S., C.M.G. Royal Colonial Institute, Northumberland-avenue, W.C.
1881. ‡Oldfield, Joseph. Lendal, York.
1896. ‡Oldham, G. S. Town Hall, Birkenhead.
1892. ‡OLDHAM, H. YULE, M.A., F.R.G.S., Lecturer in Geography in the University of Cambridge. King's College, Cambridge.
1885. ‡Oldham, John. River Plate Telegraph Company, Monte Video.
1893. *OLDHAM, R. D., F.G.S., Geological Survey of India. Care of Messrs. H. S. King & Co., 9 Pall Mall, S.W.
1863. ‡OLIVER, DANIEL, LL.D., F.R.S., F.L.S., Emeritus Professor of Botany in University College, London. 10 Kew Gardens-road, Kew, Surrey.
1887. ‡OLIVER, F. W., D.Sc., F.R.S., F.L.S., Professor of Botany in University College, London. 2 The Vale, Chelsea, S.W.
1883. §Oliver, Samuel A. Bellingham House, Wigan, Lancashire.
1889. ‡Oliver, Professor T., M.D. 7 Ellison-place, Newcastle-upon-Tyne.
1882. §Olsen, O. T., F.L.S., F.R.A.S., F.R.G.S. 116 St. Andrew's-terrace, Grimsby.
1880. *Ommanney, Rev. E. A. St. Michael's and All Angels, Portsea, Hants.
1902. ‡O'Neill, Henry, M.D. 6 College-square East, Belfast.
1902. ‡O'Neill, James, M.A. 5 College-square East, Belfast.
1883. ‡Oppert, Gustav, Professor of Sanskrit in the University of Berlin.
1902. ‡O'Reilly, Patrick Joseph. 7 North Earl-street, Dublin.
1905. §O'Riley, J. C. 70 Barnet-street, Gardens, Cape Town.
1899. ‡Orling, Axel. Moorgate Station-chambers, E.C.
1858. ‡Ormerod, T. T. Brighouse, near Halifax.
1883. ‡Orpen, Miss. St. Leonard's, Killiney, Co. Dublin.
1884. *Orpen, Lieut.-Colonel R. T., R.E. St. Leonard's, Killiney, Co. Dublin.

Year of Election.

1884. *Orpen, Rev. T. H., M.A. The Vicarage, Great Shelford, Cambridge.
1901. §Orr, Alexander Stewart. Care of Messrs. Marsland, Price, & Co., Nesbit-road, Mazagon, Bombay, India.
1905. §Orr, Professor John. Transvaal Technical Institute, Johannesburg.
1904. *Orton, K. J. P., M.A., Ph.D., Professor of Chemistry in University College, Bangor.
1899. ‡Osborn, Dr. F. A. The Châlet, Dover.
1905. §Osborn, Philip B. P.O. Box 4181, Johannesburg.
1897. ‡Osborne, James K. 40 St. Joseph-street, Toronto, Canada.
1901. ‡Osborne, W. A., D.Sc. University College, W.C.
1887. ‡O'Shea, L. T., B.Sc. University College, Sheffield.
1897. ‡Osler, E. B., M.P. Rosedale, Toronto, Canada.
1865. *Osler, Henry F. Coppy Hill, Linthurst, near Bromsgrove, Birmingham.
1884. ‡Osler, William, M.D., LL.D., F.R.S., Regius Professor of Medicine in the University of Oxford. University Museum, Oxford.
1882. **Oswald, T. R. Castle Hall, Milford Haven.*
1881. *Ottewell, Alfred D. 14 Mill Hill-road, Derby.
1896. ‡Oulton, W. Hillside, Gateacre, Liverpool.
1882. ‡Owen, Rev. C. M., M.A. St. George's, Edgbaston, Birmingham.
1903. *Owen, Edwin, M.A. Terra Nova, Birkdale, Lancashire.
1889. *Owen, Alderman H. C. Compton, Wolverhampton.
1896. §Owen, Peter. The Elms, Capenhurst, Chester.

1903. *Page, Miss Ellen Iva. Turret House, Felpham, Sussex.
1889. ‡Page, Dr. F. 1 Saville-place, Newcastle-upon-Tyne.
1883. ‡Page, George W. Fakenham, Norfolk.
1883. ‡Page, Joseph Edward. 12 Saunders-street, Southport.
1894. ‡Paget, Octavius. 158 Fenchurch-street, E.C.
1898. ‡Paget, The Right Hon. Sir R. H., Bart. Cranmore Hall, Shepton Mallet.
1875. ‡Paine, William Henry, M.D. Stroud, Gloucestershire.
1870. *Palgrave, Robert Harry Inglis, F.R.S., F.S.S. (Pres. F, 1883.) Belton, Great Yarmouth.
1896. ‡Pallis, Alexander. Tatoi, Aigburth-drive, Liverpool.
1889. ‡Palmer, Sir Charles Mark, Bart., M.P. Grinkle Park, Yorkshire.
1878. *Palmer, Joseph Edward. Rose Lawn, Ballybrack, Co. Dublin.
1866. §Palmer, William. Waverley House, Waverley-street, Nottingham.
1905. §Palmer, William. Durban, Natal.
1886. ‡Panton, George A., F.R.S.E. 73 Westfield-road, Edgbaston, Birmingham.
1880. *Parke, George Henry, F.L.S., F.G.S. St. John's, Wakefield, Yorkshire.
1904. ‡Parker, E. H., M.A. Thorneycreek, Herschel-road, Cambridge.
1893. ‡Parker, G., M.D. 14 Pembroke-road, Clifton, Bristol.
1903. §Parker, Rev. J. Dunne, LL.D., D.C.L., F.R.A.S. Bennington House, viâ Stevenage, Hertfordshire.
1905. §Parker, Hugh. P.O. Box 200, Pietermaritzburg, Natal.
1905. §Parker, John. 37 Hout-street, Cape Town.
1886. ‡Parker, Lawley. Chad Lodge, Edgbaston, Birmingham.
1905. *Parker, Thomas Edward. P.O. Box 4580, Johannesburg.
1891. ‡Parker, William Newton, Ph.D., F.Z.S., Professor of Biology in University College, Cardiff.
1899. *Parkin, John. Blaithwaite, Carlisle.
1905. *Parkin, Thomas. Blaithwaite, Carlisle.
1879. *Parkin, William. The Mount, Sheffield.

Year of Election.

1887. ‡Parkinson, James. Greystones, Langho, Blackburn.
1859. ‡Parkinson, Robert, Ph.D. Yewbarrow House, Grange-over-Sands.
1903. §Parry, Joseph, M.Inst.C.E. Woodbury, Waterloo, near Liverpool.
1883. ‡Parson, T. Cooke, M.R.C.S. Atherston House, Clifton, Bristol.
1878. ‡PARSONS, Hon. C. A., C.B., M.A., Sc.D., F.R.S., M.Inst.C.E. (Pres. G, 1904.) Holeyn Hall, Wylam-on-Tyne.
1904. ‡Parsons, Professor F. G. St. Thomas's Hospital, S.E.
1905. *Parsons, Hon. Geoffrey L. Northern Counties Club, Newcastle-on-Tyne.
1898. *Partridge, Miss Josephine M. 15 Grosvenor-crescent, S.W.
1898. ‡Pass, Alfred C. Clifton Down, Bristol.
1887. ‡PATERSON, A. M., M.D., Professor of Anatomy in the University of Liverpool.
1897. ‡Paterson, John A. 23 Walmer-road, Toronto, Canada.
1896. ‡Paton, A. A. Greenbank-drive, Wavertree, Liverpool.
1897. ‡Paton, D. Noël, M.D. 22 Forrest-road, Edinburgh.
1883. *Paton, Rev. Henry, M.A. 120 Polwarth-terrace, Edinburgh.
1884. *Paton, Hugh. Box 2400, Montreal, Canada.
1902. ‡*Patterson, Robert, F.Z.S., M.R.I.A. Ivy Dene, Malone Park, Belfast.*
1876. ‡Patterson, T. L. Maybank, Greenock.
1874. ‡Patterson, W. H., M.R.I.A. 26 High-street, Belfast.
1863. ‡PATTINSON, JOHN, F.C.S. 75 The Side, Newcastle-upon-Tyne.
1879. *Patzer, F. R. Clayton Lodge, Newcastle, Staffordshire.
1883. ‡Paul, George. 10 St. Mary's-avenue, Harrogate.
1892. ‡Paul, J. Balfour. 30 Heriot-row, Edinburgh.
1863. ‡PAVY, FREDERICK WILLIAM, M.D., LL.D., F.R.S. 35 Grosvenor-street, W.
1887. *Paxman, James. Stisted Hall, near Braintree, Essex.
1887. *Payne, Miss Edith Annie. Hatchlands, Cuckfield, Hayward's Heath.
1881. ‡Payne, J. Buxton. 15 Mosley-street, Newcastle-upon-Tyne.
1877. *Payne, J. C. Charles, J.P. Albion-place, The Plains, Belfast.
1881. ‡Payne, Mrs. Albion-place, The Plains, Belfast.
1866. ‡Payne, Joseph F., M.D. 78 Wimpole-street, W.
1888. *Paynter, J. B. Hendford Manor House, Yeovil.
1886. ‡Payton, Henry. Wellington-road, Birmingham.
1876. ‡Peace, G. H. Monton Grange, Eccles, near Manchester.
1879. ‡Peace, William K. Moor Lodge, Sheffield.
1885. ‡PEACH, B. N., F.R.S., F.R.S.E., F.G.S. Geological Survey Office, Edinburgh.
1886. *Pearce, Mrs. Horace. Collingwood, Manby-road, West Malvern.
1886. ‡*Pearsall, Howard D. 19 Willow-road, Hampstead, N.W.*
1905. §Pearse, S. P.O. Box 149, Johannesburg.
1883. ‡Pearson, Arthur A. Colonial Office, S.W.
1891. ‡Pearson, B. Dowlais Hotel, Cardiff.
1893. *Pearson, Charles E. Hillcrest, Lowdham, Nottinghamshire.
1898. §Pearson, George. Bank-chambers, Baldwin-street, Bristol.
1905. §Pearson, Professor H. H. W., M.A., F.L.S. South African College, Cape Town.
1883. ‡Pearson, Miss Helen E. Oakhurst, Birkdale, Southport.
1881. ‡Pearson, John. Glentworth House, The Mount, York.
1883. ‡Pearson, Mrs. Glentworth House, The Mount, York.
1892. ‡Pearson, J. M. John Dickie-street, Kilmarnock.
1904. ‡Pearson, Karl, M.A., F.R.S., Professor of Applied Mathematics in University College, London, W.C.
1881. ‡Pearson, Richard. 57 Bootham, York.
1889. ‡Pease, Howard. Enfield Lodge, Benwell, Newcastle-upon-Tyne.
Peckitt, Henry. Carlton Husthwaite, Thirsk, Yorkshire.

Year of Election.

1855. *PECKOVER, ALEXANDER, LL.D., F.S.A., F.L.S., F.R.G.S. Bank House, Wisbech, Cambridgeshire.
1888. ‡Peckover, Miss Alexandrina. Bank House, Wisbech, Cambridgeshire.
1885. ‡*Peddie, William, D.Sc., F.R.S.E. 2 Cameron-park, Edinburgh.*
1884. ‡Peebles, W. E. 9 North Frederick-street, Dublin.
1878. *Peek, William. Summerslea, Lingfield, Surrey.
1901. *Peel, Hon. William, M.P. 13 King's Bench-walk, Temple, E.C.
1905. §Peirson, J. Waldrie. P.O. Box 561, Johannesburg.
1878. ‡Pemberton, Charles Seaton. 44 Lincoln's Inn-fields, W.C.
1905. §Pemberton, Gustavus M. P.O. Box 93, Johannesburg.
1887. ‡PENDLEBURY, WILLIAM H., M.A., F.C.S. (Local Sec. 1899.) Woodford House, Mountfields, Shrewsbury.
1894. ‡Pengelly, Miss. Lamorna, Torquay.
1897. ‡PENHALLOW, Professor D. P., M.A. McGill University, Montreal, Canada.
1896. ‡Pennant, P. P. Nantlys, St. Asaph.
1898. ‡Pentecost, Rev. Harold, M.A. The School, Giggleswick, Yorkshire.
1889. ‡Percival, Archibald Stanley, M.A., M.B. 16 Ellison-place, Newcastle-upon-Tyne.
1898. ‡Percival, Francis W., M.A., F.R.G.S. 1 Chesham-street, S.W.
1895. ‡Percival, John, M.A., Professor of Botany in the South-Eastern Agricultural College, Wye, Kent.
1905. §Péringney, L. South African Museum, Cape Town.
1894. ‡PERKIN, A. G., F.R.S., F.R.S.E., F.C.S., F.I.C. 8 Montpelier-terrace, Hyde Park, Leeds.
1902. ‡Perkin, F. Mollwo, Ph.D. The Firs, Hengrave-road, Honor Oak Park, S.E.
1868. *PERKIN, WILLIAM HENRY, Ph.D., LL.D., D.Sc., F.R.S., F.C.S. (Pres. B, 1876; Council 1880–86). The Chestnuts, Sudbury, Harrow, Middlesex.
1884. ‡PERKIN, WILLIAM HENRY, jun., LL.D., Ph.D., F.R.S., F.R.S.E. (Pres. B, 1900; Council 1901–), Professor of Organic Chemistry in the Owens College, Manchester. Fairview, Wilbraham-road, Fallowfield, Manchester.
1864. *Perkins, V. R. Wotton-under-Edge, Gloucestershire.
1898. *Perman, E. P., D.Sc. University College, Cardiff.
1885. ‡Perrin, Miss Emily. 31 St John's Wood Park, N.W.
1886. ‡Perrin, Henry S. 31 St. John's Wood Park, N.W.
1886. ‡Perrin, Mrs. 31 St. John's Wood Park, N.W.
1874. *PERRY, JOHN, M.E., D.Sc., LL.D., F.R.S. (GENERAL TREASURER, 1904– ; Pres. G, 1902; Council 1901–04), Professor of Mechanics and Mathematics in the Royal College of Science, S.W.
1883. ‡Perry, Russell R. 34 Duke-street, Brighton.
1904. *Pertz, Miss D. F. M. 2 Cranmer-road, Cambridge.
1900. ‡Petavel, J. E. The Owens College, Manchester.
1897. ‡Peters, Dr. George A. 171 College-street, Toronto, Canada.
1898. ‡Pethick, William. Woodside, Stoke Bishop, Bristol.
1901. ‡Pethybridge, G. H. Museum of Science and Art, Dublin.
1883. ‡Petrie, Miss Isabella. Stone Hill, Rochdale.
1895. ‡PETRIE, W. M. FLINDERS, D.C.L., F.R.S. (Pres. H, 1895), Professor of Egyptology in University College, W.C.
1871. *Peyton, John E. H., F.R.A.S., F.G.S. 13 Fourth-avenue, Hove Brighton.
1886. ‡Phelps, Major-General A. 23 Augustus-road, Edgbaston, Birmingham.
1863. *PHENÉ, JOHN SAMUEL, LL.D., F.S.A., F.G.S., F.R.G.S. 5 Carlton-terrace, Oakley-street, S.W.

Year of Election.

1896. ‡Philip, George, jun. Weldon, Bidston, Cheshire.
1903. ‡Philip, James C. 20 Westfield-terrace, Aberdeen.
1905. §Philip, John W. P.O. Box 215, Johannesburg.
1892. ‡Philip, R. W., M.D. 4 Melville-crescent, Edinburgh.
1870. ‡Philip, T. D. 51 South Castle-street, Liverpool.
1853. *Philips, Rev. Edward. Hollington, Uttoxeter, Staffordshire.
1853. *Philips, Herbert. The Oak House, Macclesfield.
1877. §Philips, T. Wishart. Elizabeth Lodge, Crescent-road, South Woodford, Essex.
1863. ‡Philipson, Sir G. H. 7 Eldon-square, Newcastle-upon-Tyne.
1905. §Phillimore, Miss C. M. Shiplake House, Henley-on-Thames.
1883. ‡Phillips, Arthur G. 20 Canning-street, Liverpool.
1899. *Phillips, Charles E. S. Castle House, Shooter's Hill, Kent.
1894. ‡Phillips, Staff-Commander E. C. D., R.N., F.R.G.S. 14 Hargreaves-buildings, Chapel-street, Liverpool.
1902. ‡Phillips, J. St. J., B.E. 64 Royal-avenue, Belfast.
1890. ‡Phillips, R. W., M.A., D.Sc., F.L.S., Professor of Botany in University College, Bangor. 2 Snowdon-villas, Bangor.
1883. ‡Phillips, S. Rees. Wonford House, Exeter.
1881. ‡Phillips, William. 9 Bootham-terrace, York.
1905. §Phillp, Miss M. E. de R., B.Sc. 12 Crescent-grove, Clapham, S.W.
1898. ‡Philps, Captain Lambe. 7 Royal-terrace, Weston-super-Mare.
1884. *Pickard, Rev. H. Adair, M.A. Airedale, Oxford.
1883. *Pickard, Joseph William. Oatlands, Lancaster.
1901. §Pickard, Robert H., D.Sc. Isca, Merlin-road, Blackburn.
1885. *PICKERING, SPENCER P. U., M.A., F.R.S. Harpenden, Herts.
1884. *Pickett, Thomas E., M.D. Maysville, Mason Co., Kentucky, U.S.A.
1888. *Pidgeon, W. R. 42 Porchester-square, W.
1865. ‡PIKE, L. OWEN. 4A Marlborough-gate, Hyde Park, W.
1873. ‡Pike, W. H., M.A., Ph.D. Toronto, Canada.
1896. *Pilkington, A. C. Rocklands, Rainhill, Lancashire.
1905. §Pilling, Arnold. Royal Observatory, Cape Town.
1896. *Pilling, William. Rosario, Heene-road, West Worthing.
1905. §Pim, Miss Gertrude. Charleville, Blackrock, Co. Dublin.
1877. ‡Pim, Joseph T. Greenbank, Monkstown, Co. Dublin.
1887. ‡Pitkin, James. 56 Red Lion-street, Clerkenwell, E.C.
1875. ‡Pitman, John. Redcliff Hill, Bristol.
1883. ‡Pitt, Sydney. 16 St. Andrew's-street, Holborn-circus, E.C.
1893. *PITT, WALTER, M.Inst.C.E. South Stoke House, near Bath.
1900. *Platts, Walter. Fairmount, Bingley.
1898. ‡Playne, H. C. 28 College-road, Clifton, Bristol.
1893. ‡Plowright, Henry J. Ashdown House, Fawley, near Southampton.
1897. ‡Plummer, J. H. Bank of Commerce, Toronto, Canada.
1898. §Plummer, W. E., M.A., F.R.A.S. The Observatory, Bidston, Birkenhead.
1899. ‡Plumptre, Fitzwalter. Goodnestone, Dover.
1857. ‡Plunkett, Thomas. Ballybrophy House, Borris-in-Ossory, Queen's Co., Ireland.
1900. *Pocklington, H. Cabourn. 41 Virginia-road, Leeds.
1881. §Pocklington, Henry. 20 Park-row, Leeds.
1896. ‡Pollard, James. High Down, Hitchin, Herts.
1904. §Pollard, William. 12 Aberdare-gardens, Hampstead, N.W.
1898. ‡*POLLEN, Rev. G. C. H., F.G.S. Stonyhurst College, Blackburn.*
1896. *Pollex, Albert. Tenby House, Egerton Park, Rockferry.
1862. *Polwhele, Thomas Roxburgh, M.A., F.G.S. Polwhele, Truro, Cornwall.
1891. ‡Pomeroy, Captain Ralph. 201 Newport-road, Cardiff.

Year of
Election.

1900. *Pope, W. J., F.R.S., Professor of Chemistry in the Municipal School of Technology, Manchester. 16 Hope-street, Higher Broughton, Manchester.
1892. ‡Popplewell, W. C., M.Sc., Assoc.M.Inst.C.E. The Yew, Marple, near Stockport.
1901. §Porter, Alfred W., B.Sc. 87 Parliament Hill-mansions, Lissenden-gardens, N.W.
1883. *Porter, Rev. C. T., LL.D., D.D. All Saints' Vicarage, Southport.
1905. §Porter, J. B., Ph.D., M.Inst.C.E., Professor of Mining Engineering in the McGill University, Montreal, Canada.
1905. §Porter, Mrs. McGill University, Montreal, Canada.
1883. ‡Postgate, Professor J. P., M.A. University College, Gower-street, W.C.
1883. ‡Potter, M. C., M.A., F.L.S., Professor of Botany in the College of Science, Newcastle-upon-Tyne. 14 Highbury, Newcastle-upon-Tyne.
1886. *Poulton, Edward B., M.A., F.R.S., F.L.S., F.G.S., F.Z.S. (Pres. D, 1896; Council 1895–1901, 1905–), Professor of Zoology in the University of Oxford. Wykeham House, Banbury-road, Oxford.
1905. §Poulton, Mrs. Wykeham House, Banbury-road, Oxford.
1905. §Poulton, Miss. Wykeham House, Banbury-road, Oxford.
1905. §Poulton, Miss M. Wykeham House, Banbury-road, Oxford.
1898. *Poulton, Edward Palmer. Wykeham House, Banbury-road, Oxford
1873. *Powell, Sir Francis S., Bart., M.P., F.R.G.S. Horton Old Hall, Yorkshire; and 1 Cambridge-square, W.
1887. *Powell, Horatio Gibbs, F.R.G.S. Wood Villa, Tettenhall Wood, Wolverhampton.
1883. ‡Powell, John. Brynmill-crescent, Swansea.
1894. *Powell, Sir Richard Douglas, Bart., M.D. 62 Wimpole-street, Cavendish-square, W.
1875. ‡Powell, William Augustus Frederick. Norland House, Clifton, Bristol.
1887. §Pownall, George H. 20 Birchin-lane, E.C.
1867. ‡Powrie, James. Reswallie, Forfar.
1883. ‡Poynting, J. H., D.Sc., F.R.S. (Pres. A, 1899), Professor of Physics in the University of Birmingham. 10 Ampton-road, Edgbaston, Birmingham.
1884. *Prankerd, A. A., D.C.L. 66 Banbury-road, Oxford.
1869. *Preece, Sir William Henry, K.C.B., F.R.S., M.Inst.C.E. (Pres. G, 1888; Council 1888–95, 1896–1902.) Gothic Lodge, Wimbledon Common, S.W.; and 8 Queen Anne's-gate, S.W.
1888. *Preece, W. Llewellyn. Bryn Helen, Woodborough-road, Putney, S.W.
1904. §Prentice, Mrs. Manning. Thelema, Undercliff-road, Felixstowe.
1892. §Prentice, Thomas. Willow Park, Greenock.
1889. §Preston, Alfred Eley, M.Inst.C.E., F.G.S. 14 The Exchange, Bradford, Yorkshire.
1894. ‡Preston, Arthur E. Piccadilly, Abingdon, Berkshire.
1893. *Preston, Martin Inett. 48 Ropewalk, Nottingham.
1905. §Pretoria, The Right Rev. the Bishop of, D.D. Pretoria.
1903. §Price, Edward E. Oaklands, Oaklands-road, Bromley, Kent.
Price, J. T. Neath Abbey, Glamorganshire.
1888. ‡Price, L. L. F. R., M.A., F.S.S. (Pres. F, 1895; Council, 1898–1904.) Oriel College, Oxford.
1875. *Price, Rees. 163 Bath-street, Glasgow.
1891. ‡Price, William. 40 Park-place, Cardiff.

Year of Election.

1897. *PRICE, W. A., M.A. The Mill House, Broomfield, Chelmsford.
1897. ‡Primrose, Dr. Alexander. 196 Simcoe-street, Toronto, Canada.
1892. ‡Prince, Professor Edward E., B.A. Ottawa, Canada.
1905. §Prince, James Perrott, M.D. Durban, Natal.
1889. *Pritchard, Eric Law, M.D., M.R.C.S. 70 Fairhazel-gardens, South Hampstead, N.W.
1876. *PRITCHARD, URBAN, M.D., F.R.C.S. 26 Wimpole-street, W.
1888. ‡Probyn, Leslie C. 79 Onslow-square, S.W.
1881. §Procter, John William. Ashcroft, York.
1863. ‡Proctor, R. S. Grey-street, Newcastle-upon-Tyne.
Proctor, William. Elmhurst, Higher Erith-road, Torquay.
1884. *Proudfoot, Alexander, M.D. 100 State-street, Chicago, U.S.A.
1879. *Prouse, Oswald Milton, F.G.S. Alvington, Ilfracombe.
1872. *Pryor, M. Robert. Weston Park, Stevenage, Herts.
1871. *Puckle, Rev. T. J. Chestnut House, Huntingdon-road, Cambridge.
1873. ‡Pullan, Lawrence. Bridge of Allan, N.B.
1867. *Pullar, Sir Robert, F.R.S.E. Tayside, Perth.
1883. *Pullar, Rufus D., F.C.S. Brahan, Perth.
1891. ‡Pullen, W. W. F. University College, Cardiff.
1903. §Pullen-Burry, Miss. Care of Mrs. Kilvington, Coniston, Avondale-road, South Croydon.
1904. ‡Punnett, R. C. Caius College, Cambridge.
1905. §Purcell, W. F. South African Museum, Cape Town.
1905. §Purcell, Mrs. W. F. South African Museum, Cape Town.
1885. ‡PURDIE, THOMAS, B.Sc., Ph.D., F.R.S., Professor of Chemistry in the University of St. Andrews. 14 South-street, St. Andrews, N.B.
1881. ‡Purey-Cust, Very Rev. Arthur Percival, M.A., Dean of York. The Deanery, York.
1874. ‡PURSER, FREDERICK, M.A. Rathmines Castle, Dublin.
1866. ‡PURSER, Professor JOHN, M.A., LL.D., M.R.I.A. (Pres. A, 1902.) Rathmines Castle, Dublin.
1878. ‡Purser, John Mallet. 3 Wilton-terrace, Dublin.
1884. *Purves, W. Laidlaw. 20 Stratford-place, Oxford-street, W.
1905. §Purvis, Mr. P.O. Box 744, Johannesburg.
1860. *Pusey, S. E. B. Bouverie. Pusey House, Faringdon.
1898. *Pye, Miss E. St. Mary's Hall, Rochester.
1883. §Pye-Smith, Arnold. Willesley, Park Hill Rise, Croydon.
1883. ‡Pye-Smith, Mrs. Willesley, Park Hill Rise, Croydon.
1868. ‡PYE-SMITH, P. H., M.D., F.R.S. 48 Brook-street, W.; and Guy's Hospital, S.E.
1879. ‡Pye-Smith, R. J. 350 Glossop-road, Sheffield.

1893. ‡Quick, James. University College, Bristol.
1894. ‡Quick, Professor W. J. University of Missouri, Columbia, U.S.A.

1855. *Radstock, The Right Hon. Lord. Mayfield, Woolston, Southampton.
1887. *Ragdale, John Rowland. The Beeches, Stand, near Manchester.
1905. §Raine, Miss. P.O. Box 788, Johannesburg.
1905. §Raine, Robert. P.O. Box 1091, Johannesburg.
1898. *Raisin, Miss Catherine A., D.Sc. Bedford College, York-place, Baker-street, W.
1896. *RAMAGE, HUGH. The Technical Institute, Norwich.
1894. *RAMBAUT, ARTHUR A., M.A., D.Sc., F.R.S., F.R.A.S., M.R.I.A. Radcliffe Observatory, Oxford.
1863. ‡RAMSAY, ALEXANDER. 2 Cowper-road, Acton, Middlesex, W.

Year of Election.

1884. ‡Ramsay, George G., LL.D., Professor of Humanity in the University of Glasgow. 6 The College, Glasgow.

1884. ‡Ramsay, Mrs. G. G. 6 The College, Glasgow.

1861. ‡Ramsay, John. Kildalton, Argyllshire.

1885. ‡Ramsay, Major. Straloch, N.B.

1889. ‡Ramsay, Major R. G. W. Bonnyrigg, Edinburgh.

1876. *RAMSAY, Sir WILLIAM, K.C.B., Ph.D., F.R.S. (Pres. B, 1897; Council 1891–98), Professor of Chemistry in University College, London. 19 Chester-terrace, Regent's Park, N.W.

1883. ‡Ramsay, Lady. 19 Chester-terrace, Regent's Park, N.W.

1869. *Rance, H. W. Henniker, LL.D. 10 Castletown-road, W.

1901. ‡*Rankin, James, M.A., B.Sc. The University, Glasgow.*

1868. *Ransom, Edwin, F.R.G.S. 24 Ashburnham-road, Bedford.

1893. ‡Ransom, W. B., M.D. The Pavement, Nottingham.

1863. ‡RANSOM, WILLIAM HENRY, M.D., F.R.S. The Pavement, Nottingham.

1861. ‡RANSOME, ARTHUR, M.A., M.D., F.R.S. (Local Sec. 1861.) Sunnyhurst, Deane Park, Bournemouth.

Ransome, Thomas. Hest Bank, near Lancaster.

1889. ‡Rapkin, J. B. Thrale Hall, Streatham, S.W.

Rashleigh, Jonathan. 3 Cumberland-terrace, Regent's Park, N.W.

1903. §Rastall, R. H. Christ's College, Cambridge.

1864. ‡Rate, Rev. John, M.A. Fairfield, East Twickenham.

1892. *Rathbone, Miss May. Backwood, Neston, Cheshire.

1874. ‡RAVENSTEIN, E. G., F.R.G.S., F.S.S. (Pres. E, 1891.) 2 York-mansions, Battersea Park, S.W.

1889. ‡Rawlings, Edward. Richmond House, Wimbledon Common, Surrey.

1870. ‡Rawlins, G. W. The Hollies, Rainhill, Liverpool.

1887. ‡Rawson, Harry. Earlswood, Ellesmere Park, Eccles, Manchester.

1905. §Rawson, Colonel Herbert E., R.E. Army Headquarters, Pretoria.

1868. *RAYLEIGH, The Right Hon. Lord, M.A., D.C.L., LL.D., Pres.R.S., F.R.A.S., F.R.G.S. (PRESIDENT, 1884; TRUSTEE, 1883– ; Pres. A, 1882; Council, 1878–83), Professor of Natural Philosophy in the Royal Institution. Terling Place, Witham, Essex.

1895. ‡Raynbird, Hugh, jun. Garrison Gateway Cottage, Old Basing, Basingstoke.

1883. *Rayne, Charles A., M.D., M.R.C.S. St. Mary's Gate, Lancaster.

1897. *Rayner, Edwin Hartree, M.A. 19 Tiviot Dale, Stockport.

1896. *READ, CHARLES H., F.S.A. (Pres. H, 1899). British Museum, W.C.

1902. ‡Reade, R. H. Wilmount, Dunmurry.

1870. ‡READE, THOMAS MELLARD, F.G.S. Blundellsands, Liverpool.

1884. §Readman, J. B., D.Sc., F.R.S.E. 4 Lindsay-place, Edinburgh.

1899. ‡Reaster, James William. 68 Linden-grove, Nunhead, S.E.

1852. *REDFERN, Professor PETER, M.D. (Pres. D, 1874.) 4 Lower-crescent, Belfast.

1892. ‡Redgrave, Gilbert R., Assoc.Inst.C.E. The Elms, Westgate-road, Beckenham, Kent.

1889. ‡Redmayne, J M. Harewood, Gateshead.

1889. ‡Redmayne, Norman. 26 Grey-street, Newcastle-upon-Tyne.

1890. *Redwood, Sir Boverton, F.R.S.E., F.C.S. Wadham Lodge, Wadham-gardens, N.W.

1861. ‡REED, Sir EDWARD JAMES, K.C.B., F.R.S. Broadway-chambers, Westminster, S.W.

1889. ‡Reed, Rev. George. Bellingham Vicarage, Bardon Mill, Carlisle.

1905. §Reed, J. Howard. Coal Exchange, Market-place, Manchester.

1891. *Reed, Thomas A. Bute Docks, Cardiff.

Year of Election.

1894. *Rees, Edmund S. G. Dunscar, Oaken, near Wolverhampton.
1891. *Rees, I. Treharne, M.Inst.C.E. Blaenypant, near Newport, Monmouthshire.
1888. ‡Rees, W. L. 11 North-crescent, Bedford-square, W.C.
1875. ‡Rees-Mogg, W. Wooldridge. Cholwell House, near Bristol.
1897. ‡Reeve, Richard A. 22 Shuter-street, Toronto, Canada.
1903. §Reeves, E. A., F.R.G.S. 1 Savile-row, W.
1901. *Reid, Andrew T. 10 Woodside-terrace, Glasgow.
1904. §Reid, Arthur H. P.O. Box 120, Cape Town.
1881. §Reid, Arthur S., M.A., F.G.S. Trinity College, Glenalmond, N.B.
1883. *REID, CLEMENT, F.R.S., F.L.S., F.G.S. 28 Jermyn-street, S.W.
1903. *Reid, Mrs. E. M., B.Sc. 36 Sarre-road, West Hampstead, N.W.
1892. ‡REID, E. WAYMOUTH, B.A., M.B., F.R.S., Professor of Physiology in University College, Dundee.
1889. ‡Reid, G., Belgian Consul. Leazes House, Newcastle-upon-Tyne.
1901. *Reid, Hugh. Belmont, Springburn, Glasgow.
1876. ‡Reid, James. 10 Woodside-terrace, Glasgow.
1901. ‡Reid, John. 7 Park-terrace, Glasgow.
1904. ‡Reid, P. J. German Cottage, Marske-by-the-Sea.
1897. ‡Reid, T. Whitehead, M.D. St. George's House, Canterbury.
1892. ‡Reid, Thomas. University College, Dundee.
1887. *Reid, Walter Francis. Fieldside, Addlestone, Surrey.
1893. ‡*Reinach, Baron Albert von. Frankfort s. M., Prussia.*
1875. ‡REINOLD, A. W., M.A., F.R.S. (Council 1890–95), Professor of Physics in the Royal Naval College, Greenwich, S.E.
1863. ‡RENALS, E. 'Nottingham Express' Office, Nottingham.
1894. ‡RENDALL, Rev. G. H., M.A., Litt.D. Charterhouse, Godalming.
1891. *Rendell, Rev. James Robson, B.A. Whinside, Whalley-road, Accrington.
1903. §RENDLE, Dr. A. B., M.A., F.L.S. 47 Wimbledon Park-road, Wimbledon.
1885. ‡Rennett, Dr. 12 Golden-square, Aberdeen.
1889. *Rennie, George B. 20 Lowndes-street, S.W.
1905. *Renton, James Hall. Rowfold Grange, Billinghurst, Sussex.
1905. §Reunert, Clive. Windybrow, Johannesburg.
1905. §Reunert, John. Windybrow, Johannesburg.
1904. §REUNERT, THEODORE, M.Inst.C.E. P.O. Box 92, Johannesburg.
1905. §Reyersbach, Louis. P.O. Box 149, Johannesburg.
1883. *Reynolds, A. H. Bank House, 135 Lord-street, Southport.
1871. ‡REYNOLDS, JAMES EMERSON, M.D., D.Sc., F.R.S., Pres.C.S., M.R.I.A. (Pres. B, 1893; Council 1893–99). 29 Campden Hill-court, W.
1900. **Reynolds, Miss K. M. 4 Colinette-road, Putney, S.W.*
1870. *REYNOLDS, OSBORNE, M.A., LL.D., F.R.S., M.Inst.C.E. (Pres. G, 1887.) 19 Lady Barn-road, Fallowfield, Manchester.
1896. ‡Rhodes, Albert. Fieldhurst, Liversidge, Yorkshire.
1890. ‡Rhodes, J. M., M.D. Ivy Lodge, Didsbury.
1877. *Rhodes, John. 360 Blackburn-road, Accrington, Lancashire.
1884. ‡Rhodes, Lieut.-Colonel William. Quebec, Canada.
1899. *RHYS, Professor JOHN, D.Sc. (Pres. H, 1900). Jesus College, Oxford.
1877. *Riccardi, Dr. Paul, Secretary of the Society of Naturalists. Riva Muro, 14, Modena, Italy.
1905. §Rich, Miss Florence. Roedean School, near Brighton.
1891. ‡Richards, D. 1 St. Andrew's-crescent, Cardiff.
1891. ‡Richards, H. M. 1 St. Andrew's-crescent, Cardiff.
1889. ‡Richards, Professor T. W., Ph.D. Cambridge, Massachusetts, U.S.A.
1869. *Richardson, Charles. 3 Cholmley-villas, Long Ditton, Surrey.

Year of Election.

1882. ‡Richardson, Rev. George, M.A. Walcote, Winchester.
1884. *Richardson, George Straker. Isthmian Club, Piccadilly, W.
1889. ‡Richardson, Hugh, M.A. Bootham School, York.
1884. *Richardson, J. Clarke. Derwen Fawr, Swansea.
1896. *Richardson, Nelson Moore, B.A., F.E.S. Montevideo, Chickerell, near Weymouth.
1901. *Richardson, Owen Willans. Trinity College, Cambridge.
1870. ‡Richardson, Ralph, F.R.S.E. 10 Magdala-place, Edinburgh.
1889. ‡Richardson, Thomas, J.P. 7 Windsor-terrace, Newcastle-upon-Tyne.
1876. §Richardson, William Haden. City Glass Works, Glasgow.
1891. ‡Riches, Carlton H. 21 Dumfries-place, Cardiff.
1891. §Riches, T. Harry. 8 Park-grove, Cardiff.
1886. ‡Richmond, Robert. Heathwood, Leighton Buzzard.
1883. *RIDEAL, SAMUEL, D.Sc., F.C.S. 28 Victoria-street, S.W.
1902. ‡Ridgeway, William, M.A., Professor of Archæology in the University of Cambridge. Fen Ditton, Cambridge.
1894. §RIDLEY, E. P., F.G.S. (Local Sec. 1895.) Burwood, Westerfield-road, Ipswich.
1861. ‡Ridley, John. 19 Belsize-park, Hampstead, N.W.
1881. *Rigg, Arthur. 150 Blomfield-terrace, W.
1883. *RIGG, EDWARD, M.A. Royal Mint, E.
1892. ‡Rintoul, D., M.A. Clifton College, Bristol.
*RIPON, The Most Hon. the Marquess of, K.G., G.C.S.I., C.I.E., D.C.L., F.R.S., F.L.S., F.R.G.S. (VICE-PRESIDENT 1906.) 9 Chelsea Embankment, S.W.
1892. ‡Ritchie, R. Peel, M.D., F.R.S.E. 1 Melville-crescent, Edinburgh.
1905. §Ritchie, Prof. W., M.A. South African College, Cape Town.
1889. ‡Ritson, U. A. 1 Jesmond-gardens, Newcastle-upon-Tyne.
1903. *Rivers, W. H. R., M.D. St. John's College, Cambridge.
1900. ‡Rixon, F. W., B.Sc. 79 Green-lane, Heywood, Lancashire.
1898. §Robb, Alfred A. Lisnabreeny House, Belfast.
1902. *Roberts, Bruno. 30 St. George's-square, Regent's Park, N.W.
1887. *Roberts, Evan. 30 St. George's-square, Regent's Park, N.W.
1881. ‡Roberts, R. D., M.A., D.Sc., F.G.S. 4 Regent-street, Cambridge.
1879. ‡Roberts, Samuel, M.P. The Towers, Sheffield.
1879. ‡Roberts, Samuel, jun. The Towers, Sheffield.
1896. §Roberts, Thomas J. Ingleside, Park-road, Huyton, near Liverpool.
1904. *Robertson, Miss Agnes. 9 Elsworthy-terrace, Primrose Hill, N.W.
1883. ‡Robertson, Alexander. Montreal, Canada.
1883. ‡Robertson, George H. Plas Newydd, Llangollen.
1883. ‡Robertson, Mrs. George H. Plas Newydd, Llangollen.
1897. §ROBERTSON, Sir GEORGE S., K.C.S.I. (Pres. E, 1900.) 1 Pump-court, Temple, E.C.
1905. §Robertson, Dr. G. W. Office of the Medical Officer of Health, Cape Town.
1897. §Robertson, Professor J. W., C.M.G., LL.D. The Macdonald College, St. Anne de Bellevue, Quebec, Canada.
1901. *Robertson, Robert, B.Sc., M.Inst.C.E. 154 West George-street, Glasgow.
1905. §Robertson, Professor T. E. Transvaal Technical Institute, Johannesburg.
1892. ‡Robertson, W. W. 3 Parliament-square, Edinburgh.
1898. §Robinson, Charles E., M.Inst.C.E. Holne Cross, Ashburton, South Devon.
1903. ‡Robinson, G. H. 1 Weld-road, Southport.
1905. §Robinson, Harry. Ulster-chambers, Greenmarket-square, Cape Town.

Year of Election.

1897. ‡Robinson, Haynes. St. Giles's Plain, Norwich.
1887. §Robinson, Henry, M.Inst.C.E. 13 Victoria-street, S.W.
1902. ‡Robinson, Herbert C. Holmfield, Aigburth, Liverpool.
1902. ‡Robinson, James, M.A., F.R.G.S. Dulwich College, Dulwich, S.E.
1888. §Robinson, John, M.Inst.C.E. 8 Vicarage-terrace, Kendal.
1878. ‡Robinson, John L. 198 Great Brunswick-street, Dublin.
1895. *Robinson, Joseph Johnson. 8 Trafalgar-road, Birkdale, Southport.
1905. §Robinson, Dr. Leland. 6 Victoria-walk, Woodstock, Cape Town.
1876. ‡Robinson, M. E. 6 Park-circus, Glasgow.
1899. *Robinson, Mark, M.Inst.C.E. 9 Belsize-grove, N.W.
1887. ‡Robinson, Richard. Bellfield Mill, Rochdale.
1881. ‡Robinson, Richard Atkinson. 195 Brompton-road, S.W.
1875. *Robinson, Robert, M.Inst.C.E. Beechwood, Darlington.
1884. ‡Robinson, Stillman. Columbus, Ohio, U.S.A.
1901. ‡Robinson, T. Eaton. 33 Cecil-street West, Glasgow.
1863. ‡Robinson, T. W. U. Houghton-le-Spring, Durham.
1904. §Robinson, Theodore R. 25 Campden Hill-gardens, W.
1904. §Robinson, W. H. Kendrick House, Victoria-road, Penarth.
1891. ‡Robinson, William, M.Inst.C.E., Professor of Engineering in University College, Nottingham.
1888. ‡*Robottom, Arthur. 3 St. Alban's-villas, Highgate-road, N.W.*
1870. *Robson, E. R. Palace Chambers, 9 Bridge-street, Westminster S.W.
1872. *Robson, William. 5 Gillsland-road, Merchiston, Edinburgh.
1896. ‡Rodger, Alexander M. The Museum, Tay Street, Perth.
1885. *Rodger, Edward. 1 Clairmont-gardens, Glasgow.
1885. *Rodriguez, Epifanio. New Adelphi Chambers, 6 Robert-street, Adelphi, W.C.
1866. ‡Roe, Sir Thomas. Grove-villas, Litchurch.
1905. §Roebuck, William Denison. 259 Hyde Park-road, Leeds.
1905. §Rogers, A. W., M.A., F.G.S. South African Museum, Cape Town.
1898. ‡Rogers, Bertram, M.D. (Local Sec. 1898.) 11 York-place, Clifton, Bristol.
1890. *Rogers, L. J., M.A., Professor of Mathematics in the University of Leeds. 15 Regent Park-avenue, Leeds.
1883. ‡Rogers, Major R. Alma House, Cheltenham.
1884. *Rogers, Walter. 14 Gerald-road, S.W.
1889. ‡Rogerson, John. Croxdale Hall, Durham.
1897. ‡Rogerson, John. Barrie, Ontario, Canada.
1876. ‡Rollit, Sir A. K., M.P., B.A., LL.D., D.C.L., F.R.A.S., Hon. Fellow K.C.L. 45 Belgrave-square, S.W.
1891. ‡Rönnfeldt, W. 43 Park-place, Cardiff.
1905. §Rooth, Edward. Pretoria.
1881. *Roper, W. O. Beechfield, Yealand Conyers, Carnforth.
1855. *Roscoe, Sir Henry Enfield, B.A., Ph.D., LL.D., D.C.L., F.R.S. (President, 1887; Pres. B, 1870, 1884; Council 1874-81; Local Sec. 1861.) 10 Bramham-gardens, S.W.
1905. §Rose, Miss G. 45 De Pary's-avenue, Bedford.
1905. §Rose, Miss G. Mabel. Ashley Lodge, Oxford.
1883. *Rose, J. Holland, Litt.D. 11 Endlesham-road, Balham, S.W.
1905. §Rose, John G. Government Analytical Laboratory, Cape Town.
1894. *Rose, T. K., D.Sc, Chemist and Assayer to the Royal Mint. Royal Mint, E.
1905. *Rosedale, Rev. H. G., D.D., F.S.A. St. Peter's Vicarage, 13 Ladbroke-gardens, W.
1905. *Rosedale, Rev. W. E. Willenhall, Staffordshire.
1905. §Rosen, Jacob. 1 Hopkins-street, Yeoville, Transvaal.

Year of Election.

1905. §Rosen, Julius. Clifton Grange, Jarvie-street, Jeppestown, Transvaal.
1900. ‡Rosenhain, Walter, B.A. 185 Monument-road, Edgbaston, Birmingham.
1885. ‡Ross, Alexander. Riverfield, Inverness.
1887. ‡Ross, Edward. Marple, Cheshire.
1859. *Ross, Rev. James Coulman. Wadworth Hall, Doncaster.
1902. §Ross, John Callender. 46 Holland-street, Campden Hill, W.
1901. ‡Ross, Major RONALD, C.B., F.R.S., Professor of Tropical Medicine and Parasitology in the University of Liverpool. 36 Bentley-road, Liverpool.
1869. *ROSSE, The Right Hon. the Earl of, K.P., B.A., D.C.L., LL.D., F.R.S., F.R.A.S., M.R.I.A. Birr Castle, Parsonstown, Ireland.
1891. *Roth, H. Ling. 32 Prescot-street, Halifax, Yorkshire.
1893. ‡Rothera, G. B. Sherwood Rise, Nottingham.
1865. *Rothera, George Bell. Hazlewood, Forest-grove, Nottingham.
1905. §Rothkugel, R. Care of Messrs. D. Isaacs & Co., Cape Town.
1901. *Rottenburg, Paul, LL.D. Care of Messrs. Leister, Bock, & Co., Glasgow.
1899. *Round, J. C., M.R.C.S. 19 Crescent-road, Sydenham Hill, S.E.
1884. *Rouse, M. L. Hollybank, Hayne-road, Beckenham.
1901. ‡Rouse, W. H. D. Perse School, Cambridge.
1905. §Rousselet, Charles F. 2 Pembridge-crescent, Bayswater, W.
1861. ‡ROUTH, EDWARD J., M.A., Sc.D., F.R.S., F.R.A.S., F.G.S. St. Peter's College, Cambridge.
1883. ‡Rowan, Frederick John. 134 St. Vincent-street, Glasgow.
1903. *Rowe, Arthur W., M.B., F.G.S. 1 Cecil-street, Margate.
1877. ‡ROWE, J. BROOKING, F.L.S., F.S.A. 16 Lockyer-street, Plymouth.
1890. ‡Rowley, Walter, F.S.A. Alderhill, Meanwood, Leeds.
1881. *ROWNTREE, JOHN S. Mount-villas, York.
1881. *Rowntree, Joseph. 38 St. Mary's, York.
1876. ‡Roxburgh, John. 7 Royal Bank-terrace, Glasgow.
1885. ‡Roy, John. 33 Belvidere-street, Aberdeen.
1899. ‡Rubie, G. S. Belgrave House, Folkestone-road, Dover.
1875. *RÜCKER, Sir A. W., M.A., D.Sc., F.R.S., Principal of the University of London. (PRESIDENT, 1901; TRUSTEE, 1898– ; GENERAL TREASURER, 1891–98; Pres. A, 1894; Council 1888–91.) 19 Gledhow-gardens, South Kensington, S.W.
1869. §RUDLER, F. W., F.G.S. 18 St. George's-road, Kilburn, N.W.
1901. *Rudorf, C. C. G., Ph.D., B.Sc. 26 Weston-park, Crouch End, N.
1905. *Ruffer, Marc Armand, C.M.G., M.A., M.D., B.Sc. Quarantine International Board, Alexandria.
1905. §Ruffer, Mrs. Alexandria.
1904. ‡Ruhemann, Dr. S. 3 Selwyn-gardens, Cambridge.
1896. *Rundell, T. W., F.R.Met.Soc. 25 Castle-street, Liverpool.
1887. ‡*Ruscoe, John. Ferndale, Gee Cross, near Manchester.*
1904. ‡Russell, E. J., D.Sc., Professor of Chemistry in the South-Eastern Agricultural College, Wye, Kent.
1889. ‡Russell, The Right Hon. Earl. Amberley Cottage, Maidenhead.
1875. *Russell, The Hon. F. A. R. Dunrozel, Haslemere.
1884. ‡*Russell, George. 13 Church-road, Upper Norwood, S.E.*
Russell, John. 39 Mountjoy-square, Dublin.
1890. ‡Russell, Sir J. A., LL.D. Woodville, Canaan-lane, Edinburgh.
1905. §Russell, Rev. J. M. Ardentrave, Tamboer's Kloof, Cape Town.
1883. *Russell J. W. 131 Woodstock-road, Oxford.
1852. *Russell, Norman Scott. Arts Club, Dover-street, W.
1876. ‡Russell, Robert, F.G.S. 1 Sea View, St. Bees, Carnforth.
1886. ‡Russell, Thomas H. 3 Newhall-street, Birmingham.

Year of Election.

1852. *RUSSELL, WILLIAM J., Ph.D., F.R.S., V.P.C.S. (Pres. B, 1873; Council 1873–80.) 34 Upper Hamilton-terrace, St. John's Wood, N.W.
1886. ‡Rust, Arthur. Eversleigh, Leicester.
1897. ‡Rutherford, A. Toronto, Canada.
1905. §Ryan, Pierce. Rosebank House, Rosebank, Cape Town.
1889. ‡Ryder, W. J. H. 52 Jesmond-road, Newcastle-upon-Tyne.
1897. ‡Ryerson, G. S., M.D. Toronto, Canada.
1898. §Ryland, C. J. SoutherndownHouse, Clifton, Bristol.
1865. ‡Ryland, Thomas. The Redlands, Erdington, Birmingham.

1903. ‡Sadler, M. E., LL.D., Professor of Education in the Victoria University, Manchester.
1883. ‡Sadler, Robert. 7 Lulworth-road, Birkdale, Southport.
1871. ‡Sadler, Samuel Champernowne. St. Peter's Club, 96 Buckingham Palace-road, S.W.
1903. §Sagar, J. The Poplars, Savile Park, Halifax.
1881. ‡Salkeld, William. 4 Paradise-terrace, Darlington.
1873. *Salomons, Sir David, Bart., F.G.S. Broomhill, Tunbridge Wells.
1904. §Salter, A. E., D.Sc., F.G.S. 20 Shell-road, Loampit Hill, Lewisham, S.E.
1887. ‡Samson, C. L. Carmona, Kersal, Manchester.
1861. *Samson, Henry. 6 St. Peter's-square, Manchester.
1901. ‡Samuel, John S., J.P., F.R.S.E. City Chambers, Glasgow.
1883. ‡Sanderson, Surgeon-General Alfred. East India United Service Club, St. James's-square, S.W.
1893. ‡Sanderson, F. W., M.A. The School, Oundle.
1883. ‡Sanderson, Lady Burdon. 64 Banbury-road, Oxford.
Sandes, Thomas, A.B. Sallow Glin, Tarbert, Co. Kerry.
1896. §Saner, John Arthur, Assoc.M.Inst.C.E. Highfield, Northwich.
1896. ‡Saner, Mrs. Highfield, Northwich.
1892. ‡Sang, William D. Tylehurst, Kirkcaldy, Fife.
1903. ‡Sankey, Captain H. R., R.E. Bawmore, Bilton, Rugby.
1886. ‡Sankey, Percy E. 44 Russell-square, W.C.
1905. §Sargant, E. B. Quarry Hill, Reigate.
1896. *Sargant, Miss Ethel. Quarry Hill, Reigate.
1896. ‡Sargant, W. L. Quarry Hill, Reigate.
1905. §Sargent, Miss Helen A., B.A. Huguenot College, Wellington, Cape Colony.
1901. ‡Sarruf, N. Y. 'Al Mokattam,' Cairo.
1886. ‡Sauborn, John Wentworth. Albion, New York, U.S.A.
1886. ‡Saundby, Robert, M.D. 83A Edmund-street, Birmingham.
1900. *Saunder, S. A. Fir Holt, Crowthorne, Berks.
1868. ‡Saunders, A., M.Inst.C.E. King's Lynn.
1886. ‡Saunders, C. T. Temple-row, Birmingham.
1903. *Saunders, Miss E. R. Newnham College, Cambridge.
1881. ‡SAUNDERS, HOWARD, F.L.S., F.Z.S. 7 Radnor-place, W.
1883. ‡Saunders, Rev. J. C. Cambridge.
1846. ‡SAUNDERS, TRELAWNEY W., F.R.G.S. 3 Elmfield-on-the-Knowles, Newton Abbot, Devon.
1884. ‡SAUNDERS, Dr. WILLIAM, C.M.G., LL.D. Experimental Farm, Ottawa, Canada.
1887. ‡Savage, Rev. Canon E. B., M.A., F.S.A. St. Thomas' Vicarage, Douglas, Isle of Man.
1883. ‡Savage, W. W. 109 St. James's-street, Brighton.
1883. ‡Savery, G. M., M.A. The College, Harrogate.

Year of Election.

1901. ‡Sawers, W. D. 1 Athole Gardens-place, Glasgow.

1887. §SAYCE, Rev. A. H., M.A., D.D. (Pres. H, 1887), Professor of Assyriology in the University of Oxford. Queen's College, Oxford.

1884. ‡Sayre, Robert H. Bethlehem, Pennsylvania, U.S.A.

1883. *Scarborough, George. Whinney Field, Halifax, Yorkshire.

1903. §SCARISBRICK, Sir CHARLES, J.P. Scarisbrick Lodge, Southport.

1903. ‡Scarisbrick, Lady. Scarisbrick Lodge, Southport.

1879. *SCHÄFER, E. A., LL.D., D.Sc., F.R.S., M.R.C.S. (GEN. SEC. 1895–1900; Pres. I, 1894; Council 1887–93), Professor of Physiology in the University of Edinburgh.

1888. *SCHARFF, ROBERT F., Ph.D., B.Sc., Keeper of the Natural History Department, Museum of Science and Art, Dublin.

1880. *Schemmann, Louis Carl. Hamburg. (Care of Messrs. Allen Everitt & Sons, Birmingham.)

1883. ‡Schofield, William. Alma-road, Birkdale, Southport.

1905. §Scholer, W. Peter. Transvaal Technical Institute, Johannesburg.

1885. §Scholes, L. Ivy Cottage, Parade, Parkgate, Cheshire.

1905. §Schonland, S., Ph.D. Albany Museum, Grahamstown, Cape Colony.

1873. *SCHUSTER, ARTHUR, Ph.D., F.R.S., F.R.A.S. (Pres. A, 1892; Council 1887–93), Professor of Physics in the Victoria University, Manchester. Kent House, Victoria Park, Manchester.

1905. §Sclander, J. E. P.O. Box 465, Cape Town.

1847. *SCLATER, PHILIP LUTLEY, M.A., Ph.D., F.R.S., F.L.S., F.G.S., F.R.G.S., F.Z.S. (GENERAL SECRETARY 1876–81; Pres. D, 1875; Council 1864–67, 1872–75.) Odiham Priory, Winchfield.

1883. *SCLATER, W. LUTLEY, M.A., F.Z.S. South African Museum, Cape Town.

1905. §Sclater, Mrs. W. L. Crossroads, Baker-road, Wynberg, Cape Colony.

1867. ‡SCOTT, ALEXANDER. Clydesdale Bank, Dundee.

1881. *SCOTT, ALEXANDER, M.A., D.Sc., F.R.S., F.C.S. Royal Institution, Albemarle-street, W.

1878. *Scott, Arthur William, M.A., Professor of Mathematics and Natural Science in St. David's College, Lampeter.

1881. ‡Scott, Miss Charlotte Angas, D.Sc. Bryn Mawr College, Pennsylvania, U.S.A.

1889. *SCOTT, D. H., M.A., Ph.D., F.R.S., F.L.S. (GENERAL SECRETARY, 1900–03; Pres. K, 1896.) The Old Palace, Richmond, Surrey.

1885. ‡Scott, George Jamieson. Bayview House, Aberdeen.

1857. *SCOTT, ROBERT H., M.A., D.Sc., F.R.S., F.R.Met.S. 6 Elm Park-gardens, S.W.

1884. *Scott, Sydney C. 28 The Avenue, Gipsy Hill, S.E.

1902. §Scott, William R. The University, St. Andrew's, Scotland.

1895. ‡*Scott-Elliot, Professor G. F., M.A., B.Sc., F.L.S. Ainslea, Scotstounhill, Glasgow.*

1883. ‡Scrivener, Mrs. Haglis House, Wendover.

1895. §Scull, Miss E. M. L. St. Edmund's, 10 Worsley-road, Hampstead, N.W.

1890. *Searle, G. F. C., M.A., F.R.S. Wyncote, Hills-road, Cambridge.

1859. ‡Seaton, John Love. The Park, Hull.

1880. ‡SEDGWICK, ADAM, M.A., F.R.S. (Pres. D, 1899.) 4 Cranmer-road Cambridge.

1905. §Sedgwick, C. F. Strand-street, Cape Town.

1861. *SEELEY, HARRY GOVIER, F.R.S., F.L.S., F.G.S., F.R.G.S., F.Z.S., Professor of Geology in King's College, London. 25 Palace Gardens-terrace, Kensington, W.

Year of Election.

1891. ‡Selby, Arthur L., M.A., Professor of Physics in University College, Cardiff.
1893. ‡SELBY-BIGGE, L. A., C.B., M.A. Board of Education, Whitehall S.W.
1855. ‡Seligman, H. L. 27 St. Vincent-place, Glasgow.
1879. ‡Selim, Adolphus. 21 Mincing-lane, E.C.
1904. ‡Sell, W. J. 19 Lensfield-road, Cambridge.
1904. ‡Sella, Professor Alfonso. Istituto Fisico, Rome.
1897. ‡Selous, F. C., F.R.G.S. Alpine Lodge, Worplesden, Surrey.
1885. ‡Semple, Dr. A. United Service Club, Edinburgh.
1888. *SENIER, ALFRED, M.D., Ph.D., F.C.S., Professor of Chemistry in Queen's College, Galway.
1888. *SENNETT, ALFRED R., A.M.Inst.C.E. 15 Heath-mansions, Hampstead, N.W.
1870. *Sephton, Rev. J. 90 Huskisson-street, Liverpool.
1905. §Serrurier, Louis C. Ashley, Sea Point, Cape Town.
1901. ‡Service, Robert. Janefield Park, Maxwelltown, Dumfries.
1892. ‡Seton, Miss Jane. 37 Candlemaker-row, Edinburgh.
1895. *Seton-Karr, H. W. 31 Lingfield-road, Wimbledon, Surrey.
1892. *SEWARD, A.C., M.A., F.R.S., F.G.S. (Pres. K, 1903; Council, 1901– ; Local Sec. 1904.) Westfield, Huntingdon-road, Cambridge.
1868. ‡Sewell, Philip E. Catton, Norwich.
1904. ‡Sewell, R. B. Seymour. Christ's College, Cambridge.
1899. §Seymour, Henry J., B.A., F.G.S. St. Peter's, Ailesbury-road, Dublin.
1891. ‡Shackell, E W 191 Newport-road, Cardiff.
1905. *Shackleford, W. C., M.Inst.M.E. County Club, Lancaster.
1904. ‡Shackleton, Ernest H. Royal Scottish Geographical Society, Edinburgh.
1902. ‡SHAFTESBURY, The Right Hon. the Earl of, D.L. Belfast Castle, Belfast.
1867. ‡Shanks, James. Dens Iron Works, Arbroath, N.B.
1881. ‡Shann, George, M.D. Petergate, York.
1878. ‡SHARP, DAVID, M.A., M.B., F.R.S., F.L.S. Museum of Zoology, Cambridge.
1904. §Sharpe, Mrs. E. M. Drumna House, Whetstone, N.
1904. §Sharpe, Walter. Drumna House, Whetstone, N.
1883. ‡Sharples, Charles H. 7 Fishergate, Preston.
1904. ‡Sharples, George. 181 Great Cheetham-street West, Higher Broughton, Manchester.
1870. ‡Shaw, Duncan. Cordova, Spain.
1896. ‡Shaw, Frank. Ellerslie, Aigburth-drive, Liverpool.
1870. ‡Shaw, John. 21 St. James's-road, Liverpool.
1891. ‡Shaw, Joseph. 1 Temple-gardens, E.C.
1889. *Shaw, Mrs. M. S., B.Sc. Sydenham Damard Rectory, Tavistock.
1883. *SHAW, W. N., M.A., D.Sc., F.R.S. (Council 1895-1900, 1904– .) Meteorological Office, 63 Victoria-street, S.W.
1883. ‡Shaw, Mrs. W. N. 10 Moreton-gardens, South Kensington, S.W.
1904. ‡Shaw-Phillips, Miss. 19 Camden-crescent, Bath.
1903. ‡Shaw-Phillips, T., J.P. 19 Camden-crescent, Bath.
1891. ‡Sheen, Dr. Alfred. 23 Newport-road, Cardiff.
1905. §Shenstone, Miss A. Sutton Hall, Barcombe, Lewes.
1905. §Shenstone, Mrs. A. E. G. Sutton Hall, Barcombe, Lewes.
1865. ‡Shenstone, Frederick S. Sutton Hall, Barcombe, Lewes.
1881. ‡SHENSTONE, W. A., F.R.S. Clifton College, Bristol.
1885. ‡Shepherd, Rev. Alexander. Ecclesmechen, Uphall, Edinburgh.

Year of Election.

1890. ‡Shepherd, J. 80 Prince of Wales-mansions, Battersea, S.W.
1883. ‡Shepherd, James. Birkdale, Southport.
1900. §Sheppard, Thomas, F.G.S. The Municipal Museum, Hull.
1905. §Sheridan, Dr. Norman. 96 Francis-street, Bellevue, Johannesburg.
1883. ‡Sherlock, David. Rahan Lodge, Tullamore, Dublin.
1883. ‡Sherlock, Mrs. David. Rahan Lodge, Tullamore, Dublin.
1883. ‡Sherlock, Rev. Edgar. Bentham Rectory, *viâ* Lancaster.
1896. §SHERRINGTON, C. S., M.D., F.R.S. (Pres. I, 1904), Professor of Physiology in the University of Liverpool. 16 Grove-park, Liverpool.
1888. *Shickle, Rev. C. W., M.A., F.S.A. St. John's Hospital, Bath
1886. ‡Shield, Arthur H. 35A Great George-street, S.W.
1892. ‡Shields, John, D.Sc., Ph.D. Dolphingston, Tranent, Scotland
1901. ‡Shields, Thomas, M.A., B.Sc. Englefield Green, Surrey.
1902. *Shillington, T. Foulkes, J.P. Dromart, Antrim-road, Belfast.
1883. *Shillitoe, Buxton, F.R.C.S. 2 Frederick-place, Old Jewry, E.C.
1887. *SHIPLEY, ARTHUR E., M.A., F.R.S. (Council 1904- .) Christ's College, Cambridge.
1889. ‡Shipley, J. A. D. Saltwell Park, Gateshead.
1885. ‡Shirras, G. F. 16 Carden-place, Aberdeen.
1883. ‡*Shone, Isaac. Pentrefelin House, Wrexham.*
1870. *SHOOLBRED, J. N., B.A., M.Inst.C.E. 47 Victoria-street, S.W.
1888. ‡Shoppee, C. H. 22 John-street, Bedford-row, W.C.
1897. ‡SHORE, Dr. LEWIS E. St. John's College, Cambridge.
1882. ‡SHORE, T. W., M.D., B.Sc., Lecturer on Comparative Anatomy at St. Bartholomew's Hospital. Heathfield, Alleyn Park, Dulwich, S.E.
1901. ‡Short, Peter M., B.Sc. 1 Holmdene-avenue, Herne Hill, S.E.
1897. ‡Shortt, Professor Adam, M.A. Queen's University, Kingston, Ontario, Canada.
1904. *Shrubsall, F. C., M.A., M.D. Brompton Hospital, S.W.
1889. ‡Sibley, Walter K., B.A., M.B. 8 Duke Street-mansions, Grosvenor-square, W.
1883. ‡Sibly, Miss Martha Agnes. Flook House, Taunton.
1902. ‡Siddons, A. W. Harrow-on-the-Hill, Middlesex.
1883. *Sidebotham, Edward John. Erlesdene, Bowdon, Cheshire.
1877. *Sidebotham, Joseph Watson. Merlewood, Bowdon, Cheshire.
Sidney, M. J. F. Cowpen, Newcastle-upon-Tyne.
1883. *Sidebotham, James Nasmyth. Parkfield, Altrincham, Cheshire.
1873. *SIEMENS, ALEXANDER, M.Inst.C.E. 12 Queen Anne's-gate, S.W.
1905. §Siemens, Mrs. A. 12 Queen Anne's-gate, S.W.
1903. *Silberrad, Dr. Oswald. Experimental Establishment, Royal Arsenal, Woolwich.
1859. ‡Sim, John. Hardgate, Aberdeen.
1871. ‡Sime, James. Craigmount House, Grange, Edinburgh.
1898. ‡Simmons, Henry. Kingsland House, Whiteladies-road, Clifton, Bristol.
1862. ‡Simms, James. 138 Fleet-street, E.C.
1874. ‡Simms, William. Upper Queen-street, Belfast.
1901. ‡Simpson, Rev. A., B.Sc., F.G.S. 28 Myrtle-park, Crosshill, Glasgow.
1871. *SIMPSON, ALEXANDER R., M.D., Professor of Midwifery in the University of Edinburgh. 52 Queen-street, Edinburgh.
1887. ‡Simpson, F. Estacion Central, Buenos Ayres.
1863. ‡Simpson, J. B., F.G.S. Hedgefield House, Blaydon-on-Tyne.
1901. *Simpson, Professor J. Y., M.A., D.Sc., F.R.S.E. 52 Queen-street, Edinburgh.

Year of Election.

1894. §Simpson, Thomas, F.R.G.S. Fennymere, Castle Bar, Ealing, W.
1896. *Simpson, W., F.G.S. Catteral Hall, Settle, Yorkshire.
1883. ‡Simpson, Walter M. 7 York-road, Birkdale, Southport.
1887. ‡Sinclair, Dr. 268 Oxford-street, Manchester.
1905. §Sinclair, D. S. P.O. Box 3889, Johannesburg.
1874. ‡SINCLAIR, Right Hon. THOMAS (Local Sec. 1874). Dunedin, Belfast.
1897. ‡Sinnott, James. Bank of England-chambers, 12 Broad-street, Bristol.
1864. *Sircar, The Hon. Mahendra Lal, M.D., C.I.E. 51 Sankaritola, Calcutta.
1892. ‡Sisley, Richard, M.D. 1 Park-row, S.W.
1905. *Sjogren, Professor H. Natural History Museum, Stockholm, Sweden.
1902. §Skeffington, J. B., M.A., LL.D. Waterford.
1883. ‡Skillicorne, W. N. 9 Queen's-parade, Cheltenham.
1885. ‡Skinner, Provost. Inverurie, N.B.
1898. ‡SKINNER, SIDNEY, M.A. (Local Sec. 1904.) South-Western Polytechnic, Manresa-road, Chelsea, S.W.
1905. §Skyrme, C. G. 28 Norman-road, St. Leonards-on-Sea.
1905. §Slater, Dr. H. B. 75 Bree-street, Johannesburg.
1889. §Slater, Matthew B., F.L.S. Malton, Yorkshire.
1877. ‡Sleeman, Rev. Philip, L.Th., F.R.A.S. 65 Pembroke-road, Clifton, Bristol.
1849. ‡Sloper, George Elgar. Devizes.
1887. ‡Small, Evan W., M.A., B.Sc., F.G.S. The Mount, Radbourne-street, Derby.
1887. §Small, William. Lincoln-circus, The Park, Nottingham.
1903. *Smallman, Raleigh S. Wressil Lodge, Wimbledon Common.
1904. ‡Smart, Edward. Benview, Craigie, Perth, N.B.
1889. *SMART, Professor William, LL.D. (Pres. F, 1904.) Nunholme, Dowanhill, Glasgow.
1902. §Smedley, Miss Ida. 11 Mecklenburgh-square, W.C.
1898. ‡Smeeth, W. F., M.A., F.G.S. Mysore, India.
1876. ‡Smellie, Thomas D. 213 St. Vincent-street, Glasgow.
1877. ‡Smelt, Rev. Maurice Allen, M.A., F.R.A.S. Heath Lodge, Cheltenham.
1890. ‡*Smethurst, Charles. Palace House, Harpurhey, Manchester.*
1876. ‡Smieton, James. Panmure Villa, Broughty Ferry, Dundee.
1867. ‡Smieton, Thomas A. Panmure Villa, Broughty Ferry, Dundee.
1905. §Smith, Miss Adelaide. Huguenot College, Wellington, Cape Colony.
1892. ‡Smith, Alexander, B.Sc., Ph.D., F.R.S.E. The University, Chicago, Illinois, U.S.A.
1897. ‡Smith, Andrew, Principal of the Veterinary College, Toronto, Canada.
1901. *Smith, Miss Annie Lorrain. 20 Talgarth-road, West Kensington, W.
1874. *Smith, Benjamin Leigh, F.R.G.S. Oxford and Cambridge Club, Pall Mall, S.W.
1887. ‡Smith, Bryce. Rye Bank, Chorlton-cum-Hardy, Manchester.
1873. ‡Smith, C. Sidney College, Cambridge.
1905. §Smith, C. H. Fletcher's-chambers, Cape Town.
1889. *Smith, Professor C. Michie, B.Sc., F.R.S.E., F.R.A.S. The Observatory, Kodaikanal, South India.
1887. *Smith, Charles. 739 Rochdale-road, Manchester.
1886. *Smith, Mrs. Emma. Hencotes House, Hexham.
1886. ‡Smith, E. Fisher, J.P. The Priory, Dudley.
1900. §Smith, E. J. Grange House, Westgate Hill, Bradford.
1886. ‡Smith, E. O. Council House, Birmingham.
1892. ‡Smith, E. Wythe. 66 College-street, Chelsea, S.W.

Year of Election.

1901. §Smith, F. B. Care of A. Croxton Smith, Esq., Burlington House, Wandle-road, Upper Tooting, S.W.
1866. *Smith, F. C. Bank, Nottingham.
1897. ‡Smith, Sir Frank. 54 King-street East, Toronto, Canada.
1885. ‡Smith, Rev. G. A., M.A. 22 Sardinia-terrace, Glasgow.
1897. ‡Smith, G. Elliot, M.D. St. John's College, Cambridge.
1903. *Smith, H. B. Lees. 16 Park-terrace, Oxford.
1889. *Smith, H. Llewellyn, C.B., B.A., B.Sc., F.S.S. 49 St. George's square, S.W.
1888. ‡Smith, H. W. Owens College, Manchester.
1860. *Smith, Heywood, M.A., M.D. 25 Welbeck-street, Cavendish-square, W.
1876. *Smith, J. Guthrie. 5 Kirklee-gardens, Kelvinside, Glasgow.
1902. ‡Smith, J. Lorrain, M.D., Professor of Pathology in the Victoria University, Manchester.
1901. ‡SMITH, Right Hon. J. PARKER, M.P. Jordanhill, Glasgow.
1885. ‡Smith, Rev. James, B.D. Manse of Newhills, N.B.
1903. *Smith, James. Pinewood, Crathes, Aberdeen.
Smith, John Peter George. Sweyney Cliff, Coalport, Iron Bridge, Shropshire.
1883. ‡Smith, M. Holroyd. Royal Insurance-buildings, Crossley-street, Halifax.
1873. ‡Smith, Sir Swire. Lowfield, Keighley, Yorkshire.
1894. §Smith, T. Walrond. Care of Frank Henderson, Esq., 25 Pearfield-road, Forest Hill, S.E.
1867. ‡Smith, Thomas. Poole Park Works, Dundee.
1896. *Smith, Rev. W. Hodson. Newquay, Cornwall.
1892. ‡Smith, Walter A. 120 Princes-street, Edinburgh.
1885. *Smith, Watson. 34 Upper Park-road, Haverstock Hill, N.W.
1852. ‡Smith, William. Eglinton Engine Works, Glasgow.
1876. ‡Smith, William. 12 Woodside-place, Glasgow.
1883. ‡SMITHELLS, ARTHUR, B.Sc., F.R.S. (Local Sec. 1890), Professor of Chemistry in the University of Leeds.
1883. ‡Smithson, Edward Walter. 13 Lendal, York.
1883. ‡Smithson, Mrs. 13 Lendal, York.
1882. ‡Smithson, T. Spencer. Facit, Rochdale.
1874. ‡Smoothy, Frederick. Bocking, Essex.
1905. §Smuts, C. P.O. Box 1088, Johannesburg.
1857. *SMYTH, JOHN, M.A., F.C.S., F.R.M.S., M.Inst.C.E.I. Milltown, Banbridge, Ireland.
1888. *SNAPE, H. LLOYD, D.Sc., Ph.D. Balholm, Lathom-road, Southport.
1889. ‡*Snell, W. H. Lancaster Lodge, Amersham-road, Putney, S.W.*
1898. ‡Snook, Miss L. B. V. 13 Clare-road, Cotham, Bristol.
1905. §Soddy, F. The University, Glasgow.
1905. §Sollas, Miss I. B. J. Newnham College, Cambridge.
1879. *SOLLAS, W. J., M.A., Sc.D., F.R.S., F.R.S.E., F.G.S. (Pres. C, 1900; Council 1900-03), Professor of Geology in the University of Oxford. 173 Woodstock-road, Oxford.
1905. §Solomon, R. Stuart. Care of Messrs. R. M. Moss & Co., Cape Town.
1892. *SOMERVAIL, ALEXANDER. The Museum, Torquay.
1900. *SOMERVILLE, W., D.Sc. Board of Agriculture, Whitehall, S.W.
1859. *SORBY, H. CLIFTON, LL.D., F.R.S., F.G.S. (Pres. C, 1880; Council 1879-86; Local Sec. 1879.) Broomfield, Sheffield.
1879. *Sorby, Thomas W. Storthfield, Ranmoor, Sheffield.
1901. ‡Sorley, Robert. The Firs, Partickill, Glasgow.
1888. ‡SORLEY, Professor W. R., M.A. Trinity College, Cambridge.
1903. ‡Soulby, R. M. Sea Holm, Westbourne-road, Birkdale, Lancashire.
1886. ‡Southall, Alfred. Carrick House, Richmond Hill-road, Birmingham.

Year of Election.

1903. ‡Southall, Henry T. The Graig, Ross, Herefordshire.
1865. *Southall, John Tertius. Parkfields, Ross, Herefordshire.
1890. ‡Southwark, The Right Rev. E. S. Talbot, D.D., Lord Bishop of. Bishop's House, Kennington Park, S.E.
1883. ‡Spanton, William Dunnett, F.R.C.S. Chatterley House, Hanley, Staffordshire.
1890. ‡Spark, F. R. 29 Hyde-terrace, Leeds.
1893. *Speak, John. Kirton Grange, Kirton, near Boston.
1905. §Spencer, Charles Hugh. P.O. Box 2, Maraisburg, Transvaal.
1884. ‡Spencer, John, M.Inst.M.E. Globe Tube Works, Wednesbury.
1889. *Spencer, John. Newbiggin House, Kenton, Newcastle-upon-Tyne.
1864. *Spicer, Henry, B.A., F.L.S., F.G.S. 14 Aberdeen-park, Highbury, N.
1894. ‡Spiers, A. H. Gresham's School, Holt, Norfolk.
1864. *SPILLER, JOHN, F.C.S. 2 St. Mary's-road, Canonbury, N.
1864. *Spottiswoode, W. Hugh, F.C.S. 107 Sloane-street, S.W.
1854. *SPRAGUE, THOMAS BOND, M.A., LL.D., F.R.S.E. 29 Buckingham-terrace, Edinburgh.
1883. ‡Spratling, W. J., B.Sc., F.G.S. Maythorpe, 74 Wickham-road, Brockley, S.E.
1897. §Squire, W. Stevens, Ph.D. Clarendon House, 30 St. John's Wood Park, N.W.
1905. §Squire, Mrs. Clarendon House, 30 St. John's Wood Park, N.W.
1888. *Stacy, J. Sargeant. 164 Shoreditch, E.C.
1897. ‡Stafford, Joseph. Morrisburg, Ontario, Canada.
1903. §Stallworthy, Rev. George B. The Manse, Hindhead, Haslemere, Surrey.
1883. *Stanford, Edward, F.R.G.S. 12–14 Long-acre, W.C.
1905. §Stanley, Professor George H. Transvaal Technical Institute, Johannesburg.
1881. *Stanley, William Ford, F.G.S. Cumberlow, South Norwood, S.E.
1883. ‡Stanley, Mrs. Cumberlow, South Norwood, S.E.
1894. *STANSFIELD, ALFRED, D.Sc. McGill University, Montreal, Canada.
1900. *Stansfield, H., B.Sc. Whalley, near Blackburn.
1905. §Stanwell, H. B. South African College School, Cape Town.
1905. §Stanwell, Dr. St. John. P.O. Box 1050, Johannesburg.
1905. §Stapleton, Frederick. Control and Audit Office, Cape Town.
1905. *Starkey, A. H. 24 Greenhead-road, Huddersfield.
1899. ‡STARLING, E. H., M.D., F.R.S., Professor of Physiology in University College, London, W.C.
1899. §Statham, William. The Redings, Totteridge, Herts.
1898. ‡Stather, J. W., F.G.S. 16 Louis-street, Hull.
Staveley, T. K. Ripon, Yorkshire.
1894. ‡Stavert, Rev. W. J., M.A. Burnsall Rectory, Skipton-in-Craven, Yorkshire.
1873. *Stead, Charles. Red Barns, Freshfield, Liverpool.
1900. *Stead, J. E., F.R.S. Laboratory and Assay Office, Middlesbrough.
1881. ‡Stead, W. H. Orchard-place, Blackwall, E.
1881. ‡Stead, Mrs. W. H. Orchard-place, Blackwall, E.
1884. ‡Stearns, Sergeant P. U.S. Consul-General, Montreal, Canada.
1892. *STEBBING, Rev. THOMAS R. R., M.A., F.R.S. Ephraim Lodge, The Common, Tunbridge Wells.
1896. *Stebbing, W. P. D., F.G.S. 8 Playfair-mansions, Queen's Club-gardens, W.
1905. §Stebbins, Miss Inez F., B.A. Huguenot College, Wellington, Cape Town.
1884. ‡Stephen, George. 140 Drummond-street, Montreal, Canada.

Year of Election.

1884. ‡Stephen, Mrs. George. 140 Drummond-street, Montreal, Canada.
1905. §Stephen, J. M. Invernegie, Sea Point, Cape Colony.
1884. *Stephens, W. Hudson. Low-Ville, Lewis County, New York, U.S.A.
1902. ‡Stephenson, G. Cuilin, Glasnevin, Dublin.
1901. ‡Steven, William. 420 Sauchiehall-street, Glasgow.
1901. ‡Steven, Mrs. W. 420 Sauchiehall-street, Glasgow.
1880. *Stevens, J. Edward, LL.B. Le Mayals, Blackpill, R.S.O.
1900. ‡STEVENS, FREDERICK (Local Sec. 1900.) Town Clerk's Office, Bradford.
1892. ‡Stevenson, D. A., B.Sc., F.R.S.E., M.Inst.C.E. 84 George-street, Edinburgh.
1863. *STEVENSON, JAMES C., M.P. Eltham Court, Eltham, Kent.
1890. *Steward, Rev. Charles J., F.R.M.S. The Cedars, Anglesea-road, Ipswich.
1885. *Stewart, Rev. Alexander, M.D., LL.D. Murtle, Aberdeen.
1905. §Stewart, A. F. P.O. Box 107, Kimberley.
1864. ‡STEWART, CHARLES, M.A., F.R.S., F.L.S., Hunterian Professor of Anatomy and Conservator of the Museum, Royal College of Surgeons, Lincoln's Inn-fields, W.C.
1905. §Stewart, Charles. Meteorological Commission, Cape Town.
1892. ‡*Stewart, C. Hunter. 3 Carlton-terrace, Edinburgh.*
1885. ‡Stewart, David. Banchory House, Aberdeen.
1875. *Stewart, James, B.A., F.R.C.P.Ed. Dunmurry, Sneyd Park, near Clifton, Gloucestershire.
1901. *Stewart, John Joseph, M.A., B.Sc. 35 Stow Park-avenue, Newport, Monmouthshire.
1892. ‡*Stewart, Samuel. Knocknairn, Bagston, Greenock.*
1901. *Stewart, Thomas. St. George's-chambers, Cape Town.
1901. ‡Stewart, Walter, M.A., D.Sc. Gartsherrie, Coatbridge.
1901. ‡Stewart, William. Violet Grove House, St. George's-road, Glasgow.
1905. §Steyn, Dr. G. H. Kandahar, Salt River, Cape Colony.
1867. ‡Stirling, Dr. D. Perth.
1876. ‡STIRLING, WILLIAM, M.D., D.Sc., F.R.S.E., Professor of Physiology in the Owens College, Manchester.
1867. *Stirrup, Mark, F.G.S. Stamford-road, Bowdon, Cheshire.
1904. §Stobbs, J. T. Dunelm, Basford Park, Stoke-on-Trent.
1901. *Stobo, Thomas. Somerset House, Garelochhead, Dumbartonshire, N.B.
1865. *Stock, Joseph S. St. Mildred's, Walmer.
1890. ‡Stockdale, R. The Grammar School, Leeds.
1883. *STOCKER, W. N., M.A. Brasenose College, Oxford.
1898. ‡Stoddart, F. Wallis, F.I.C. Grafton Lodge, Sneyd Park, Bristol.
1898. *Stokes, Professor George J., M.A. 5 Fernhurst-villas, College-road, Cork.
1887. ‡Stone, E. D., F.C.S. Rose Lea, Alderley Edge, Cheshire.
1899. *Stone, Rev. F. J. Radley College, Abingdon.
1886. ‡Stone, Sir J. Benjamin, M.P. The Grange, Erdington, Birmingham.
1886. ‡Stone, J. H. Grosvenor-road, Handsworth, Birmingham.
1874. ‡Stone, J. Harris, M.A., F.L.S., F.C.S. 3 Dr. Johnson's-buildings, Temple, E.C.
1876. ‡Stone, Octavius C., F.R.G.S. Rothbury House, Westcliff-gardens, Bournemouth.
1905. §Stoneman, Miss Bertha, D.Sc. Huguenot College, Wellington, Cape Colony.
1857. ‡STONEY, BINDON B., LL.D., F.R.S., M.Inst.C.E., M.R.I.A., Engineer of the Port of Dublin. 14 Elgin-road, Dublin.

Year of Election.

1895. *Stoney, Miss Edith A. 30 Ledbury-road, Bayswater, W.
1878. *Stoney, G. Gerald. Oakley, Heaton-road, Newcastle-upon-Tyne.
1861. *STONEY, GEORGE JOHNSTONE, M.A., D.Sc., F.R.S., M.R.I.A. (Pres. A, 1897.) 30 Ledbury-road, Bayswater, W.
1903. *Stopes, Miss Marie, Ph.D., B.Sc. 25 Denning-road, Hampstead, N.W.
1883. ‡Stopes, Mrs. 25 Denning-road, Hampstead, N.W.
1887. *Storey, H. L. Bailrigg, Lancaster.
1884. ‡Storrs, George H. Gorse Hall, Stalybridge.
1888. *Stothert, Percy K. Woodley Grange, Bradford-on-Avon, Wilts.
1905. *Stott, Clement H. Pietermaritzburg, Natal.
1905. §Stower, Miss Alice. 34 Palace Gardens-terrace, W.
1871. *STRACHEY, Lieut.-General Sir RICHARD, R.E., G.C.S.I., LL.D., F.R.S., F.R.G.S., F.L.S., F.G.S. (Pres. E, 1875; Council, 1871–75.) 69 Lancaster-gate, Hyde Park, W.
1881. ‡STRAHAN, AUBREY, M.A., F.R.S., F.G.S. (Pres. C, 1904.) Geological Museum, Jermyn-street, S.W.
1863. ‡Straker, John. Wellington House, Durham.
1905. §Strange, Harold F. P.O. Box 2527, Johannesburg.
1881. ‡STRANGWAYS, C. Fox, F.G.S. Geological Museum, Jermyn-street, S.W.
1889. ‡Streatfeild, H. S., F.G.S. Ryhope, near Sunderland.
1879. ‡Strickland, Sir Charles W., Bart., K.C.B. Hildenley-road, Malton.
1884. ‡Stringham, Irving. The University, Berkeley, California, U.S.A.
1883. §Strong, Henry J., M.D. Colonnade House, The Steyne, Worthing.
1898. *Strong, W. M. 3 Champion-park, Denmark Hill, S.E.
1887. *Stroud, H., M.A., D.Sc., Professor of Physics in the College of Science, Newcastle-upon-Tyne.
1887. *STROUD, WILLIAM, D.Sc., Professor of Physics in the University of Leeds.
1905. §Struben, Mrs. A. P.O. Box 1228, Pretoria.
1876. *Stuart, Charles Maddock, M.A. St. Dunstan's College, Catford, S.E.
1872. *Stuart, Rev. Edward A., M.A. 5 Prince's-square, W.
1884. ‡Stuart, Dr. W. Theophilus. 183 Spadina-avenue, Toronto, Canada.
1892. ‡Stuart-Gray, Hon. Morton, M.A., F.G.S. 2 Belford-park, Edinburgh.
1896. ‡Stubbs, Miss. Torrisholme, Aigburth-drive, Sefton Park, Liverpool.
1885. ‡Stump, Edward C. 16 Herbert-street, Moss Side, Manchester.
1897. ‡Stupart, R. F. The Observatory, Toronto, Canada.
1879. *Styring, Robert. Brinkcliffe Tower, Sheffield.
1891. *Sudborough, Professor J. J., Ph.D., D.Sc. University College of Wales, Aberystwyth.
1902. §Sully, H. J. Avalon House, Priory-road, Clifton, Bristol.
1898. §Sully, T. N. Avalon House, Queen's-road, Weston-super-Mare.
1905. §Summer, A. B. Ollersett Booyseux, Transvaal.
1884. ‡Sumner, George. 107 Stanley-street, Montreal, Canada.
1887. *Sumpner, W. E., D.Sc. Technical School, Suffolk-street, Birmingham.
1883. ‡Sutcliffe, J. S., J.P. Beech House, Bacup.
1863. ‡Sutherland, Benjamin John. Thurso House, Newcastle-upon-Tyne.
1886. ‡Sutherland, Hugh. Winnipeg, Manitoba, Canada.
1892. ‡Sutherland, James B. 10 Windsor-street, Edinburgh.
1884. ‡Sutherland, J. C. Richmond, Quebec, Canada.
1863. ‡SUTTON, FRANCIS, F.C.S. Bank Plain, Norwich.
1889. ‡Sutton, William. Esbank, Jesmond, Newcastle-upon-Tyne.
1891. ‡Swainson, George, F.L.S. North Drive, St. Anne's-on-Sea, Lancashire.

Yea of Election.

1903. ‡Swallow, Rev. R. D., M.A. Chigwell School, Essex.
1905. §Swan, Miss Hilda. 58 Holland-park, W.
1881. §SWAN, Sir JOSEPH WILSON, M.A., D.Sc., F.R.S. 58 Holland-park, W.
1905. §Swan, Miss Mary E. 58 Holland-park, W.
1897. ‡Swanston, William, F.G.S. Mount Collyer Factory, Belfast.
1879. ‡Swanwick, Frederick. Whittington, Chesterfield.
1887. §SWINBURNE, JAMES, M.Inst.C.E. 82 Victoria-street, S.W.
1870. *Swinburne, Sir John, Bart. Capheaton Hall, Newcastle-upon-Tyne.
1887. *Swindells, Rupert, F.R.G.S. 22 Oxford-road, Birkdale, Southport.
1890. ‡SWINHOE, Colonel C., F.L.S. 7 Gloucester-walk, Campden Hill, W.
1873. ‡Sykes, Benjamin Clifford, M.D. St. John's House, Cleckheaton.
1895. ‡Sykes, E. R. 3 Gray's Inn-place, W.C.
1902. *Sykes, Miss Ella C. Elcombs, Lyndhurst, Hampshire.
1887. *Sykes, George H., M.A., M.Inst.C.E., F.S.A. Glencoe, 64 Elmbourne-road, Tooting Common, S.W.
1896. *Sykes, Mark L., F.R.M.S. Kensington House, Pensford, near Bristol.
1902. *Sykes, Major P. Molesworth, C.M.G. Elcombs, Lyndhurst, Hampshire.
1893. ‡Symes, Rev. J. E., M.A. 70 Redcliffe-crescent, Nottingham.
1870. ‡SYMES, RICHARD GLASCOTT, M.A., F.G.S., Geological Survey of Scotland. Sheriff Court-buildings, Edinburgh.
1905. §Symington, C. Railway Medical Office, De Aar, Cape Colony.
1903. §Symington, Howard W. Brooklands, Market Harborough.
1885. ‡SYMINGTON, JOHNSON, M.D., F.R.S., F.R.S.E. (Pres. H, 1903), Professor of Anatomy in Queen's College, Belfast.
1905. §Symmes, H. C. P.O. Box 3902, Johannesburg.
1886. ‡Symons, W. H., M.D. (Brux.), M.R.C.P., F.I.C. Guildhall, Bath.

1896. ‡Tabor, J. M. Holmwood, Harringay Park, Crouch End, N.
1898. ‡Tagart, Francis. 199 Queen's-gate, S.W.
1865. ‡Tailyour, Colonel Renny, R.E. Newmanswalls, Montrose, Forfarshire.
1894. ‡Takakusu, Jyun, B.A. 17 Worcester-terrace, Oxford.
1904. §Tallack, H. T. Clovelly, Birdhurst-road, South Croydon.
1903. *Tanner, Miss Ellen G. 48 Campden House Court, Gloucester-walk, W.
1890. ‡TANNER, H. W. LLOYD, D.Sc., F.R.S. (Local Sec. 1891), Professor of Mathematics and Astronomy in University College, Cardiff.
1897. ‡Tanner, Professor J. H. Ithaca, New York, U.S.A.
1892. *Tansley, Arthur G., M.A., F.L.S. University College, W.C.
1883. *Tapscott, R. Lethbridge, F.R.A.S. 62 Croxteth-road, Liverpool.
1878. ‡TARPEY, HUGH. Dublin.
1861. *Tarratt, Henry W. 7 Oxford and Cambridge-mansions, Hyde Park, W.
1893. ‡Tate, George, Ph.D. College of Chemistry, Duke-street, Liverpool.
1902. ‡Tate, Miss. Rantalard, Whitehouse, Belfast.
1901. ‡Taylor, Benson. 22 Hayburn-crescent, Partick, Glasgow.
1884. *Taylor, Rev. Charles, D.D. St. John's Lodge, Cambridge.
1887. ‡Taylor, G. H. Holly House, 235 Eccles New-road, Salford.
1898. ‡Taylor, Lieut.-Colonel G. L. Le M. 6 College-lawn, Cheltenham.
1887. ‡Taylor, George Spratt. 13 Queen's-terrace, St. John's Wood, N.W.
1881. **Taylor, H. A.* 69 *Addison-road, Kensington, W.*
1884. *TAYLOR, H. M., M.A., F.R.S. Trinity College, Cambridge.
1882. *Taylor, Herbert Owen, M.D. Oxford-street, Nottingham.

Year of Election.

1860. *Taylor, John, M.Inst.C.E., F.G.S. 6 Queen Street-place, E.C.
1881. *Taylor, John Francis. Holly Bank House, York.
1865. ‡Taylor, Joseph. 99 Constitution-hill, Birmingham.
1899. ‡Taylor, Robert H., Assoc.M.Inst.C.E. 5 Maison Dieu-road, Dover.
1884. *Taylor, Miss S. Oak House, Shaw, near Oldham.
1900. ‡Taylor, T. H. Yorkshire College, Leeds.
1887. ‡Taylor, Tom. Grove House, Sale, Manchester.
1895. ‡Taylor, W. A., M.A., F.R.S.E. Royal Scottish Geographical Society, Edinburgh.
1893. ‡*Taylor, W. F. Bhootan, Whitehorse-road, Croydon, Surrey.*
1894. *Taylor, W. W., M.A. 30 Banbury-road, Oxford.
1883. ‡Taylor, William, M.D. 21 Crockherbtown, Cardiff.
1901. §Taylor, William. 57 Sparkenhoe-street, Leicester.
1903. ‡Taylor, William. 61 Cambridge-road, Southport.
1901. *Teacher, John H., M.B. 32 Kingsborough-gardens, Glasgow.
1858. ‡Teale, Thomas Pridgin, M.A., F.R.S. 38 Cookridge-street, Leeds.
1885. ‡Teall, J. J. H., M.A., F.R.S., F.G.S. (Pres. C, 1893; Council 1894–1900), Director of the Geological Survey of the United Kingdom. The Museum, Jermyn-street, S.W.
1898. §Tebb, Robert Palmer. Enderfield, Chislehurst, Kent.
1879. ‡Temple, Lieutenant G. T., R.N., F.R.G.S. The Nash, near Worcester.
1882. ‡Terrill, William. 42 St. George's-terrace, Swansea.
1896. *Terry, Rev. T. R., M.A., F.R.A.S. The Rectory, East Ilsley, Newbury, Berkshire.
1892. *Tesla, Nikola. 45 West 27th-street, New York, U.S.A.
1883. ‡Tetley, C. F. The Brewery, Leeds.
1883. ‡Tetley, Mrs. C. F. The Brewery, Leeds.
1882. *Thane, George Dancer, Professor of Anatomy in University College, London, W.C.
1871. ‡Thiselton-Dyer, Sir W. T., K.C.M.G., C.I.E., M.A., B.Sc., Ph.D., LL.D., F.R.S., F.L.S. (Pres. D, 1888; Pres. K, 1895; Council 1885–89, 1895–1900.) Royal Gardens, Kew.
1870. ‡Thom, Robert Wilson. Lark Hill, Chorley, Lancashire.
1891. ‡Thomas, A. Garrod, M.D., J.P. Clytha Park, Newport, Monmouthshire.
1891. ‡Thomas, Alfred, M.P. Pen-y-lan, Cardiff.
1891. *Thomas, Miss Clara. Penurrig, Builth.
1891. ‡Thomas, Edward. 282 Bute-street, Cardiff.
1891. ‡Thomas, E. Franklin. Dan-y-Bryn, Radyr, near Cardiff.
1903. ‡Thomas, Miss Ethel N. 3 Downe-mansions, Gondar-gardens, West Hampstead, N.W.
1869. ‡Thomas, H. D. Fore-street, Exeter.
1881. ‡Thomas, J. Blount. Southampton.
1869. ‡Thomas, J. Henwood, F.R.G.S. 86 Breakspears-road, Brockley, S.E.
1880. *Thomas, Joseph William, F.C.S. Overdale, Shortlands, Kent.
1899. *Thomas, Mrs. J. W. Overdale, Shortlands, Kent.
1902. §Thomas, Miss M. B. 200 Bristol-road, Birmingham.
1904. ‡Thomas, Northcote W. 7 Coptic-street, W.C.
1883. ‡Thomas, Thomas H. 45 The Walk, Cardiff.
1898. ‡Thomas, Rev. U. Bristol School Board, Guildhall, Bristol.
1883. ‡Thomas, William. Lan, Swansea.
1886. ‡Thomas, William. 109 Tettenhall-road, Wolverhampton.
1904. Thomas, William. Bryn-heulog, Merthyr Tydfil.
1886. ‡Thomason, Yeoville. 9 Observatory-gardens, Kensington, W.
1875. ‡Thompson, Arthur. 12 St. Nicholas-street, Hereford.

Year of Election.

1891. *Thompson, Beeby, F.C.S., F.G.S. 67 Victoria-road, Northampton.
1883. ‡Thompson, Miss C. E. Heald Bank, Bowdon, Manchester.
1891. ‡Thompson, Charles F. Penhill Close, near Cardiff.
1882. ‡Thompson, Charles O. Terre Haute, Indiana, U.S.A.
1888. *Thompson, Claude M., M.A., D.Sc., Professor of Chemistry in University College, Cardiff.
1885. ‡Thompson, D'Arcy W., B.A., C.B., Professor of Zoology in University College, Dundee.
1896. *Thompson, Edward P. Paulsmoss, Whitchurch, Salop.
1883. *Thompson, Francis. Lynton, Haling Park-road, Croydon.
1904. *Thompson, G. R., B.Sc., Professor of Mining in the University of Leeds.
1891. ‡Thompson, G. Carslake. Park-road, Penarth.
1891. ‡Thompson, H. Wolcott. 9 Park-place, Cardiff.
1893. *Thompson, Harry J., M.Inst.C.E., Madras. Care of Messrs. Grindlay & Co., Parliament-street, S.W.
1883. *Thompson, Henry G., M.D. 86 Lower Addiscombe-road, Croydon.
1891. ‡Thompson, Herbert M. Whitley Batch, Llandaff.
1905. §Thompson, James. P.O. Box 312, Johannesburg.
1897. ‡Thompson, J. Barclay. 37 St. Giles's, Oxford.
1891. ‡Thompson, J. Tatham, M.B. 23 Charles-street, Cardiff.
1861. *Thompson, Joseph. Riversdale, Wilmslow, Cheshire.
1876. *Thompson, Richard. Dringcote, The Mount, York.
1883. ‡Thompson, Richard. Bramley Mead, Whalley, Lancashire.
1876. ‡Thompson, Silvanus Phillips, B.A., D.Sc., F.R.S., F.R.A.S. (Council 1897–99), Principal and Professor of Physics in the City and Guilds of London Technical College, Finsbury, E.C.
1883. *Thompson, T. H. Oldfield Lodge, Gray-road, Bowdon, Cheshire.
1896. *Thompson, W. H., M.D., D.Sc., King's Professor of Institutes of Medicine (Physiology) in Trinity College, Dublin. 14 Hatch-street, Dublin.
1896. ‡Thompson, W. P. 6 Lord-street, Liverpool.
1905. §Thompson, William. Parkside, Doncaster-road, Rotherham.
1867. ‡Thoms, William. Magdalen-yard-road, Dundee.
1894. ‡Thomson, Arthur, M.A., M.D., Professor of Human Anatomy in the University of Oxford. Exeter College, Oxford.
1890. ‡Thomson, Professor J. Arthur, M.A., F.R.S.E. Castleton House, Old Aberdeen.
1883. ‡Thomson, J. J., M.A., D.Sc, F.R.S. (Pres. A, 1896; Council 1893–95), Professor of Experimental Physics in the University of Cambridge. Trinity College, Cambridge.
1902. ‡*Thomson, J. Stuart. Marine Biological Laboratory, Plymouth.*
1901. ‡Thomson, Dr. J. T. Kilpatrick. 148 Norfolk-street, Glasgow.
1889. *Thomson, James, M.A. 22 Wentworth-place, Newcastle-upon-Tyne.
1891. ‡Thomson, John. 70A Grosvenor-street, W.
1896. ‡*Thomson, John. 3 Derwent-square, Stonycroft, Liverpool.*
1871. *Thomson, John Millar, LL.D., F.R.S. (Council 1895–1901), Professor of Chemistry in King's College, London. 85 Addison-road, W.
1874. §Thomson, William, F.R.S.E., F.C.S. Royal Institution, Manchester.
1880. §Thomson, William J. Ghyllbank, St. Helens.
1871. ‡Thornburn, Rev. David, M.A. 1 John's-place, Leith.
1905. *Thorneley, Miss L. R. Nunclose, Grassendale, Liverpool.
1887. ‡Thornton, John. 3 Park-street, Bolton.
1898. §Thornton, W. M. The Durham College of Science, Newcastle-on-Tyne.

Year of Election.

1902. ‡Thornycroft, Sir John I., F.R.S., M.Inst.C.E. Eyot Villa, Chiswick Mall, W.
1883. ‡Thorowgood, Samuel. Castle-square, Brighton.
1903. ‡Thorp, Edward. 87 Southbank-road, Southport.
1881. ‡Thorp, Fielden. Blossom-street, York.
1881. *Thorp, Josiah. 37 Pleasant-street, New Brighton, Cheshire.
1898. §Thorp, Thomas. Moss Bank, Whitefield, Manchester.
1898. ‡Thorpe, Jocelyn Field, Ph.D. Owens College, Manchester.
1871. ‡THORPE, T. E., C.B., Ph.D., LL.D., F.R.S., F.R.S.E., V.P.C.S. (Pres. B, 1890; Council 1886–92), Principal of the Government Laboratories, Clement's Inn-passage, W.C.
1883. §Threlfall, Henry Singleton, J.P. 1 London-street, Southport.
1899. §THRELFALL, RICHARD, M.A., F.R.S. 30 George-road, Edgbaston, Birmingham.
1896. §Thrift, William Edward, M.A., Professor of Natural and Experimental Philosophy in the University of Dublin. 80 Grosvenor-square, Rathmines, Dublin.
1868. ‡THUILLIER, General Sir H. E. L., R.A., C.S.I., F.R.S., F.R.G.S. Tudor House, Richmond Green, Surrey.
1904. §Thurston, Edgar. Government Museum, Madras.
1889. ‡Thys, Captain Albert. 9 Rue Briderode, Brussels.
1870. ‡Tichborne, Charles R. C., LL.D., F.C.S., M.R.I.A. Apothecaries' Hall of Ireland, Dublin.
1873. *TIDDEMAN, R. H., M.A., F.G.S. 175 Banbury-road, Oxford.
1905. §Tietz, Heinrich, B.A., Ph.D. South African College, Cape Town.
1874. ‡TILDEN, WILLIAM A., D.Sc., F.R.S., Treas.C.S. (Pres. B, 1888, Council 1898–1904), Professor of Chemistry in the Royal College of Science, London. The Oaks, Northwood, Middlesex.
1883. ‡Tillyard, A. I., M.A. Fordfield, Cambridge.
1883. ‡Tillyard, Mrs. Fordfield, Cambridge.
1896. §Timmis, Thomas Sutton. Cleveley, Allerton, Liverpool.
1899. ‡Tims, H. W. Marett, M.A., M.D., F.L.S. 10 Bateman-street, Cambridge.
1902. §Tipper, Charles J. R., B.Sc. 21 Greenside, Kendal.
1905. §Tippett, A. M., A.M.Inst.C.E. Cape Government Railways, Cape Town.
1900. §Tocher, J. F., F.I.C. 5 Chapel-street, Peterhead, N.B.
1876. ‡Todd, Rev. Dr. Tudor Hall, Forest Hill, S.E.
1891. ‡Todd, Richard Rees. Portuguese Consulate, Cardiff.
1897. ‡Todhunter, James. 85 Wellesley-street, Toronto, Canada.
1889. §Toll, John M. 49 Newsham-drive, Liverpool.
1857. ‡Tombe, Rev. Canon. Glenealy, Co. Wicklow.
1888. ‡Tomkins, Rev. Henry George. Park Lodge, Weston-super-Mare.
1905. §Tonkin, Samuel. Rosebank, near Cape Town.
1875. ‡Torr, Charles Hawley. St. Alban's Tower, Mansfield-road, Sherwood, Nottingham.
1884. *Torrance, Rev. Robert, D.D. Guelph, Ontario, Canada.
1873. ‡Townend, W. H. Heaton Hall, Bradford, Yorkshire.
1875. ‡Townsend, Charles. St. Mary's, Stoke Bishop, Bristol.
1901. ‡Townsend, J. S. E., M.A., F.R.S., Professor of Physics in the University of Oxford. New College, Oxford.
1876. *TRAIL, J. W. H., M.A., M.D., F.R.S., F.L.S., Regius Professor of Botany in the University of Aberdeen.
1883. ‡TRAILL, A., M.D., LL.D., Provost of Trinity College, Dublin. Ballylough, Bushmills, Ireland.

Year of Election.

1870. ‡TRAILL, WILLIAM A. Giant's Causeway Electric Tramway, Portrush, Ireland.
1868. ‡TRAQUAIR, RAMSAY H., M.D., LL.D., F.R.S., F.G.S. (Pres. D, 1900), Keeper of the Natural History Collections, Museum of Science and Art, Edinburgh.
1902. ‡Travers, Ernest J. Dunmurry, Co. Antrim.
1884. ‡Trechmann, Charles O., Ph.D., F.G.S. Hartlepool.
1868. ‡Trehane, John. Exe View Lawn, Exeter.
1891. ‡Treharne, J. Ll. 92 Newport-road, Cardiff.
1887. *Trench-Gascoigne, Mrs. F. R. Lotherton Hall, Parlington, Aberford, Leeds.
1903. ‡Trenchard, Hugh. The Firs, Clay Hill, Enfield.
1889. ‡*Trendell, Edwin James, J.P. Abbey House, Abingdon, Berkshire.*
1905. §TREVOR-BATTYE, A., F.R.G.S. Chilbolton, Stockbridge, R.S.O.
1884. ‡Tribe, Paul C. M. 44 West Oneida-street, Oswego, New York, U.S.A.
1879. ‡Trickett, F. W. 12 Old Haymarket, Sheffield.
1871. ‡TRIMEN, ROLAND, M.A., F.R.S., F.L.S., F.Z.S. Ovingdean, King Charles-road, Surbiton Hill.
1860. §TRISTRAM, Rev. HENRY BAKER, D.D., LL.D., F.R.S., Canon of Durham. The College, Durham.
1902. §Tristram, Rev. J. F., M.A., B.Sc. 20 Chandos-road, Chorlton-cum-Hardy, Manchester.
1884. *Trotter, Alexander Pelham. 8 Richmond-terrace, Whitehall, S.W.
1885. §TROTTER, COUTTS, F.G.S., F.R.G.S. 10 Randolph-crescent, Edinburgh.
1891. ‡Trounce, W. J. 67 Newport-road, Cardiff.
1887. *TROUTON, FREDERICK T., M.A., Sc.D., F.R.S., Professor of Physics in University College, W.C.
1898. §Trow, Albert Howard, D.Sc., F.L.S., Professor of Botany in University College, Cardiff. 50 Clive-road, Penarth.
1885. *Tubby, A. H., F.R.C.S. 25 Weymouth-street, Portland-place, W.
1847. *Tuckett, Francis Fox. Frenchay, Bristol.
1888. ‡Tuckett, William Fothergill, M.D. 18 Daniel-street, Bath.
1871. ‡Tuke, Sir J. Batty, M.D., M.P. Balgreen, Gorgie, Edinburgh.
1883. ‡TUPPER, The Hon. Sir CHARLES, Bart., G.C.M.G., C.B. Ottawa, Canada.
1905. §Turmeau, Charles. Claremont, Victoria Park, Wavertree, Liverpool.
1892. ‡Turnbull, Alexander R. Ormiston House, Hawick.
1855. ‡Turnbull, John. 37 West George-street, Glasgow.
1901. §Turnbull, Robert, B.Sc. Department of Agriculture and Technical Instruction, Dublin.
1901. ‡Turner, A. Crosbie. 65 Bath-street, Glasgow.
1893. ‡TURNER, DAWSON, M.B. 37 George-square, Edinburgh.
1905. §Turner, Dr. G. 54 Government-buildings, Pretoria.
1894. *TURNER, H. H., M.A., D.Sc., F.R.S., F.R.A.S., Professor of Astronomy in the University of Oxford. The Observatory, Oxford.
1905. §Turner, Rev. Thomas, St. Saviour's Vicarage, 50 Fitzroy-street, W.
1886. *TURNER, THOMAS, A.R.S.M., F.C.S., F.I.C., Professor of Metallurgy in the University of Birmingham. 35 Wellington-road, Edgbaston, Birmingham.
1863. *TURNER, Sir WILLIAM, K.C.B., LL.D., D.C.L., F.R.S., F.R.S.E. (PRESIDENT, 1900; Pres. H, 1889, 1897), Principal of the University of Edinburgh. 6 Eton-terrace, Edinburgh.
1893. ‡TURNEY, Sir JOHN, J.P. Alexandra Park, Nottingham.
1890. *Turpin, G. S., M.A., D.Sc. High School, Nottingham.
1886. **Twigg, G. H. 56 Claremont-road, Handsworth, Birmingham.*
1898. ‡Twiggs, H. W. 65 Victoria-street, Bristol.
1899. ‡Twisden, John R., M.A. 14 Gray's Inn-square, W.C.

Year of Election.

1888. ‡Tyack, Llewelyn Newton. University College, Bristol.
1865. §TYLOR, EDWARD BURNETT, D.C.L., LL.D., F.R.S. (Pres. H, 1884; Council 1896–1902), Professor of Anthropology in the University of Oxford. Museum House, Oxford.
1883. ‡Tyrer, Thomas, F.C.S. Stirling Chemical Works, Abbey-lane, Stratford, E.
1897. ‡Tyrrell, J. B., M.A., B.Sc. Ottawa, Canada.

1884. *Underhill, G. E., M.A. Magdalen College, Oxford.
1888. ‡Underhill, H. M. 7 High-street, Oxford.
1886. ‡Underhill, Thomas, M.D. West Bromwich.
1903. ‡Underwood, Captain J. C. 60 Scarisbrick New-road, Southport.
1885. §Unwin, Howard. 1 Newton-grove, Bedford Park, Chiswick, W.
1883. §Unwin, John. Eastcliffe Lodge, Southport.
1876. *UNWIN, W. C., F.R.S., M.Inst.C.E. (Pres. G, 1892; Council, 1892–99.) 7 Palace Gate-mansions, Kensington, W.
1887. ‡Upton, Francis R. Orange, New Jersey, U.S.A.
1876. ‡Ure, John F. 6 Claremont-terrace, Glasgow.
1866. ‡Urquhart, William W. Rosebay, Broughty Ferry, by Dundee.
1898. ‡Usher, Thomas. 3 Elmgrove-road, Cotham, Bristol.
1902. §Ussher, R. J. Cappagh House, Cappagh, Co. Waterford.
1880. ‡USSHER, W. A. E., F.G.S. 28 Jermyn-street, S.W.
1905. §Uttley, E. A. Electrical Inspector to the Rhodesian Government, Bulawayo.

1885. ‡Vachell, Charles Tanfield, M.D. 38 Charles-street, Cardiff.
1896. ‡Vacher, Francis. 7 Shrewsbury-road, Birkenhead.
1887. *Valentine, Miss Anne. The Elms, Hale, near Altrincham.
1905. §Van der Byl, J. A. P.O. Irene, Transvaal.
1884. ‡Van Horne, Sir W. C., K.C.M.G. Dorchester-street West, Montreal, Canada.
1883. *Vansittart, The Hon. Mrs. A. A. Haywood House, Oaklands-road, Bromley, Kent.
1868. ‡Varley, Frederick H., F.R.A.S. Mildmay Park Works, Mildmay-avenue, Stoke Newington, N.
1865. *VARLEY, S. ALFRED. Arrow Works, Jackson-road, Holloway, N.
1903. ‡Varwell, H. B. 2 Pennsylvania Park, Exeter.
1884. ‡Vasey, Charles. 112 Cambridge-gardens, W.
1895. §Vaughan, D. T. Gwynne. Botanical Laboratory, The University, Glasgow.
1905. §Vaughan, E. L. Eton College, Windsor.
1875. ‡Vaughan, Miss. Burlton Hall, Shrewsbury.
1883. ‡Vaughan, William. 42 Sussex-road, Southport.
1881. §VELEY, V. H., M.A., D.Sc., F.R.S. 20 Bradmore-road, Oxford.
1873. *VERNEY, Sir EDMUND H., Bart., F.R.G.S. Claydon House, Winslow, Bucks.
1883. *Verney, Lady. Claydon House, Winslow, Bucks.
1904. *Vernon, H. M., M.A., M.D. 3 Bevington-road, Oxford.
1896. *Vernon, Thomas T. 24 Waterloo-road, Waterloo, Liverpool.
1896. *Vernon, William. Wyborne Gate, Birkdale, Southport.
1890. *Villamil, Lieut.-Colonel R. de, R.E. Carlisle Lodge, Rickmansworth.
1899. *VINCENT, Professor SWALE, M.B. Physiological Laboratory, University of Manitoba, Winnipeg, Canada.
1883. *VINES, SYDNEY HOWARD, M.A., D.Sc., F.R.S., F.L.S. (Pres. K, 1900; Council, 1894–97), Professor of Botany in the University of Oxford. Headington Hill, Oxford.

Year of Election.

1902. §Vinycomb, T. B. Riverside, Holywood, Co. Down.
1904. §Volterra, Professor Vito. Regia Universita, Rome.

1904. §Wace, A. J. B. Pembroke College, Cambridge.
1886. *Wackrill, Samuel Thomas, J.P. 33 Portland-street, Leamington.
1902. ‡Waddell, Rev. C. H. The Vicarage, Saintfield.
1860. ‡Waddingham, John. Guiting Grange, Winchcombe Gloucestershire.
1900. ‡Waddington, Dr. C. E. 2 Marlborough-road, Manningham, Bradford.
1888. ‡Wadworth, H. A. Breinton Court, near Hereford.
1890. §WAGER, HAROLD W. T., F.R.S., F.L.S. (Pres. K, 1905.) Hendre, Horsforth-lane, Far Headingley, Leeds.
1900. ‡ *Wagstaff, C. J. L., B.A. 8 Highfield-place, Manningham, Bradford.*
1891. ‡Wailes, T. W. 23 Richmond-road, Cardiff.
1902. ‡Wainwright, Joel. Finchwood, Marple Bridge, Stockport.
1884. ‡Wait, Charles E., Professor of Chemistry in the University of Tennessee. Knoxville, Tennessee, U.S.A.
1870. ‡WAKE, CHARLES STANILAND. Welton, near Brough, East Yorkshire.
1905. §Wakefield, Captain E. W. Strickland Gate House, Kendal.
1884. ‡Waldstein, Professor C., M.A., Ph.D. King's College, Cambridge.
1891. ‡ *Walford, Edward, M.D. Thanet House, Cathedral-road, Cardiff.*
1894. ‡WALFORD, EDWIN A., F.G.S. 21 West Bar, Banbury.
1882. *Walkden, Samuel, F.R.Met.S. Downside, Whitchurch, Tavistock.
1893. §Walker, Alfred O., F.L.S. Ulcombe Place, Maidstone, Kent.
1890. ‡Walker, A. Tannett. The Elms, Weetwood, Leeds.
1901. *Walker, Archibald, M.A., F.I.C. 7 Crown-terrace, Glasgow.
1897. *WALKER, B. E., D.C.L., F.G.S. (Local Sec. 1897.) Canadian Bank of Commerce, Toronto, Canada.
1885. ‡Walker, Mr. Baillie. 52 Victoria-street, Aberdeen.
1883. ‡Walker, Mrs. Emma. 13 Lendal, York.
1904. §Walker, E. R. 19 Roe-lane, Southport.
1891. ‡Walker, Frederick W. Tannett. Carr Manor, Meanwood, Leeds.
1905. §Walker, G. M. Lloyd's-buildings, Burg-street, Cape Town.
1894. *WALKER, G. T., M.A., D.Sc., F.R.S., F.R.A.S. Meteorological Office, Simla, India.
1897. ‡Walker, George Blake. Tankersley Grange, near Barnsley.
1866. ‡Walker, H. Westwood, Newport, by Dundee.
1896. ‡Walker, Horace. Belvidere-road, Prince's Park, Liverpool.
1866. *WALKER, J. FRANCIS, M.A., F.G.S., F.L.S. 45 Bootham, York.
1890. ‡Walker, Dr. James. 19 Springfield, Dundee.
1894. *WALKER, JAMES, M.A. 30 Norham-gardens, Oxford.
1866. ‡Walker, S. D. 38 Hampden-street, Nottingham.
1884. ‡Walker, Samuel. Woodbury, Sydenham Hill, S.E.
1888. ‡Walker, Sydney F. Bloomfield-crescent, Bath.
1887. ‡Walker, T. A. 15 Great George-street, S.W.
1883. ‡Walker, Thomas A. 7 Cambridge-road, Southport.
1896. ‡Walker, W. J. D. Glenhanna, Laurencetown, Co. Down, Ireland,
1895. ‡WALKER, WILLIAM G., A.M.Inst.C.E. 47 Victoria-street, S.W.
1896. §Walker, Colonel William Hall, M.P. Gateacre, Liverpool.
1883. ‡Wall, Henry. 14 Park-road, Southport.
1863. ‡WALLACE, ALFRED RUSSEL, D.C.L., F.R.S., F.L.S., F.R.G.S. (Pres. D 1876; Council 1870–72.) Broadstone, Wimborne, Dorset.
1897. ‡Wallace, Chancellor. Victoria University, Toronto, Canada.
1905. §Wallace, R. W. 2 Harcourt-buildings, Temple, E.C.
1901. ‡Wallace, William, M.A., M.D. 25 Newton-place, Glasgow.

Year of Election.

1887. *WALLER, AUGUSTUS D., M.D., F.R.S. 32 Grove End-road, N.W
1905. §Waller, Mrs. 32 Grove End-road, N.W.
1889. *Wallis, Arnold J., M.A. 5 Belvoir-terrace, Cambridge.
1895. ‡WALLIS, E. WHITE, F.S.S. Sanitary Institute, Parkes Museum, Margaret-street, W.
1883. ‡Wallis, Rev. Frederick. Caius College, Cambridge.
1886. ‡Wallis, Whitworth, F.S.A. Chevening, Montague-road, Edgbaston, Birmingham.
1894. *WALMISLEY, A. T., M.Inst.C.E. 9 Victoria-street, Westminster, S.W.
1887. ‡Walmsley, J. Monton Lodge, Eccles, Manchester.
1891. §Walmsley, R. M., D.Sc. Northampton Institute, Clerkenwell, E.C.
1905. §Walsh, Albert. Kenilworth, Cape Colony.
1903. ‡Walsh, W. T. H. Toynbee Hall, Whitechapel, E.
1895. ‡WALSINGHAM, The Right Hon. Lord, LL.D., F.R.S. Merton Hall, Thetford.
1902. *Walter, Miss L. Edna. 38 Woodberry-grove, Finsbury Park, N.
1904. *Walters, William, jun. Albert House, Newmarket.
1881. ‡Walton, Thomas, M.A. Oliver's Mount School, Scarborough.
1904. ‡Ward, A. H. M., B.A. Lenoxvale, Belfast.
1887. ‡WARD, A. W., M.A., Litt.D., Master of Peterhouse, Cambridge.
1881. §Ward, George, F.C.S. Buckingham-terrace, Headingley, Leeds.
1879. ‡WARD, H. MARSHALL, D.Sc., F.R.S., F.L.S. (Pres. K, 1897; Council 1890–97), Professor of Botany in the University of Cambridge. New Museums, Cambridge.
1880. *Ward, J. Wesney. 4 Chepstow-mansions, Pembridge-villas, Bayswater, W.
1890. ‡Ward, Alderman John. Moor Allerton House, Leeds.
1874. §Ward, John, J.P., F.S.A. Lenoxvale, Belfast.
1887. ‡WARD, JOHN, F.G.S. 23 Stafford-street, Longton, Staffordshire.
1857. ‡Ward, John S. Prospect Hill, Lisburn, Ireland.
1887. ‡Ward, Thomas. Brookfield House, Northwich.
1882. ‡Ward, William. Cleveland Cottage, Hill-lane, Southampton.
1867. ‡Warden, Alexander J. 23 Panmure-street, Dundee.
1858. ‡Wardle, Sir Thomas, F.G.S. St. Edward-street, Leek, Staffordshire.
1884. ‡Wardwell, George J. 31 Grove-street, Rutland, Vermont, U.S.A.
1887. *Waring, Richard S. Standard Underground Cable Co., 16th-street, Pittsburg, Pennsylvania, U.S.A.
1878. ‡WARINGTON, ROBERT, F.R.S., F.C.S. High Bank, Harpenden, St. Albans, Herts.
1905. §Warlow, Dr. G. B. 15 Hamilton-street, Birkenhead.
1884. *Warner, James D. 199 Baltic-street, Brooklyn, U.S.A.
1896. ‡Warrand, Major-General, R.E. Westhorpe, Southwell, Middlesex.
1887. ‡WARREN, Lieut.-General Sir CHARLES, R.E., K.C.B., G.C.M.G., F.R.S., F.R.G.S. (Pres. E, 1887.) Athenæum Club, S.W.
1893. ‡Warwick, W. D. Balderton House, Newark-on-Trent.
1875. *WATERHOUSE, Major-General J. Hurstmead, Eltham, Kent.
1905. §Watermeyer, F. S. Survey Camp, Katikula, South Africa.
1904. ‡Waters, A. H., B.A. 48 Devonshire-road, Cambridge.
1870. ‡Waters, A. T. H., M.D. 60 Bedford-street, Liverpool.
1900. §Waterston, David, M.D., F.R.S.E. 23 Colinton-road, Edinburgh.
1892. ‡Waterston, James H. 37 Lutton-place, Edinburgh.
1875. ‡Watherston, Rev. Alexander Law, M.A., F.R.A.S. The Grammar School, Hinckley, Leicestershire.
1884. ‡Watson, A. G., D.C.L. Uplands, Wadhurst, Sussex.

Year of Election.

1901. *WATSON, ARNOLD THOMAS, F.L.S. Southwold, Tapton Crescent-road, Sheffield.
1886. *Watson, C. J. Alton Cottage, Botteville-road, Acock's Green, Birmingham.
1883. ‡Watson, C. Knight, M.A. 49 Bedford-square, W.C.
1892. §Watson, G., Assoc.M.Inst.C.E. Stonegate, Pool-in-Wharfedale, Leeds.
1885. ‡Watson, Deputy Surgeon-General G. A. Hendre, Overton Park, Cheltenham.
1884. ‡Watson, John. Queen's University, Kingston, Ontario, Canada.
1889. §Watson, John, F.I.C. P.O. Box 1026, Johannesburg, South Africa.
1863. ‡Watson, Joseph. Bensham-grove, Gateshead.
1905. §Watson, Dr. R. W. Ladysmith, Cape Colony.
1863. ‡Watson, R. Spence, LL.D., F.R.G.S. Bensham-grove, Gateshead.
1867. ‡Watson, Thomas Donald. 16 St. Mary's-road, Bayswater, W.
1894. *WATSON, Professor W., D.Sc., F.R.S. 7 Upper Cheyne-row, S.W.
1892. §Watson, William, M.D. The Lea, Corstorphine, Midlothian.
1879. *WATSON, WILLIAM HENRY, F.C.S., F.G.S. The Crofts, Seascale, Cumberland.
1882. ‡Watt, Alexander. 29 Grange Mount, Claughton, Birkenhead.
1884. ‡Watt, D. A. P. 284 Upper Stanley-street, Montreal, Canada.
1901. §Watt, Henry Anderson. Ardenslate House, Hunter's Quay, Argyllshire.
1875. *WATTS, JOHN, B.A., D.Sc. Merton College, Oxford.
1884. *Watts, Rev. Canon Robert R. The Red House, Bemerton, Salisbury.
1896. ‡Watts, W. H. Elm Hall, Wavertree, Liverpool.
1873. *WATTS, W. MARSHALL, D.Sc. 166 Venner-road, Sydenham, S.E.
1883. *WATTS, W. W., M.A., M.Sc., F.R.S., Sec.G.S. (Pres. C, 1903; Council 1902–), Assistant Professor of Geology in the University of Birmingham. Holmwood, Bracebridge-road, Sutton Coldfield.
1870. §Watts, William, F.G.S. Little Don Waterworks, Langsett, near Penistone.
1891. ‡Waugh, James. Higher Grade School, 110 Newport-road, Cardiff.
1905. §Way, E. J. Post Office, Benoni, Transvaal.
1869. ‡Way, Samuel James. Adelaide, South Australia.
1905. §Way, W. A., M.A. The College, Graaf Reinet, South Africa.
1905. §Webb, Miss Dora. Gezina School, Pretoria.
1871. ‡Webb, Richard M. 72 Grand-parade, Brighton.
1891. §Webber, Thomas. The Laurels, 83 Newport-road, Roath, Cardiff.
1859. ‡Webster, John. Edgehill, Aberdeen.
1884. *Wedekind, Dr. Ludwig, Professor of Mathematics at Karlsruhe. Jahnstrasse 5, Karlsruhe.
1903. §Weekes, R. W., A.M.Inst.C.E. 65 Hayes-road, Bromley, Kent.
1889. ‡Weeks, John G. Bedlington.
1890. *WEISS, F. ERNEST, D.Sc., F.L.S., Professor of Botany in the Victoria University, Manchester.
1886. ‡Weiss, Henry. Westbourne-road, Birmingham.
1905. §Welby, Miss F. A. Hamilton House, Hall-road, N.W.
1865. ‡Welch, Christopher, M.A. United University Club, Pall Mall East, S.W.
1902. ‡Welch, R. J. 49 Lonsdale-street, Belfast.
1894. ‡Weld, Miss. Conal More, Norham-gardens, Oxford.
1876. *WELDON, Professor W. F. R., M.A., F.R.S., F.L.S. (Pres. D, 1898.) Merton Lea, Oxford.

Year of Election.

1880. *Weldon, Mrs. Merton Lea, Oxford.
1897. ‡Welford, A. B., M.B. Woodstock, Ontario, Canada.
1881. §Wellcome, Henry S. Snow Hill-buildings, E.C.
1881. ‡Wells, Rev. Edward, M.A. West Dean Rectory, Salisbury.
1894. ‡*Wells, J. G. Selwood House, Shobnall-street, Burton-on-Trent.*
1883. ‡Welsh, Miss. Girton College, Cambridge.
1881. *WENLOCK, The Right Hon. Lord., G.C.S.I., G.C.I.E., K.C.B. (VICE-PRESIDENT, 1906.) Escrick Park, Yorkshire.
Wentworth, Frederick W. T. Vernon. Wentworth Castle, near Barnsley, Yorkshire.
1864. *Were, Anthony Berwick. Roslyn, Walland's Park, Lewes.
1886. *Wertheimer, Julius, B.A., B.Sc., F.C.S., Principal of and Professor of Chemistry in the Merchant Venturers' Technical College, Bristol.
1865. ‡Wesley, William Henry. Royal Astronomical Society, Burlington House, W.
1853. ‡West, Alfred. Holderness-road, Hull.
1898. ‡West, Charles D. Imperial University, Tokyo, Japan.
1853. ‡West, Leonard. Summergangs Cottage, Hull.
1900. §West, William, F.L.S. 26 Woodville-terrace, Horton-lane, Bradford.
1903. §Westaway, F. W. 1 Pemberley-crescent, Bedford.
1897. ‡Western, Alfred E. 36 Lancaster-gate, W.
1882. *Westlake, Ernest, F.G.S. Fordingbridge, Salisbury.
1882. ‡Westlake, Richard. Portswood, Southampton.
1882. ‡WETHERED, EDWARD B., F.G.S. 4 St. Margaret's-terrace, Cheltenham.
1900. ‡Wethey, E. R., M.A., F.R.G.S. 4 Cunliffe-villas, Manningham, Bradford.
1904 §Weymouth, E. S., M.A. 27 Southampton-street, Strand, W.C.
1878. *Wheeler, W. H., M.Inst.C.E. Wyncote, Boston, Lincolnshire.
1888. §Whelen, John Leman. 18 Frognal, Hampstead, N.W.
1893. *WHETHAM, W. C. D., M.A., F.R.S. Upwater Lodge, Cambridge.
1888. *Whidborne, Miss Alice Maria. Charanté, Torquay.
1888. *Whidborne, Miss Constance Mary. Charanté, Torquay.
1879. *WHIDBORNE, Rev. GEORGE FERRIS, M.A., F.G.S. Hammerwood Lodge, East Grinstead, Sussex.
1898. *Whipple, Robert S. Scientific Instrument Company, Cambridge.
1883. *Whitaker, T. Walton House, Burley-in-Wharfedale.
1859. *WHITAKER, WILLIAM, B.A., F.R.S., F.G.S. (Pres. C, 1895; Council 1890-96.) 3 Campden-road, Croydon.
1884. ‡Whitcher, Arthur Henry. Dominion Lands Office, Winnipeg, Canada.
1886. ‡Whitcombe, E. B. Borough Asylum, Winson Green, Birmingham.
1897. ‡Whitcombe, George. The Wotton Elms, Wotton, Gloucester.
1886. ‡WHITE, A. SILVA. (ASSISTANT SECRETARY.) Burlington House, W.
1898. ‡White, George. Clare-street House, Bristol.
1882. ‡White, Rev. George Cecil, M.A. Nutshalling Rectory, Southampton.
1904. ‡White, H. Lawrence, B.A. 2 St. Margaret's-terrace, Cheltenham.
1885. *White, J. Martin. Balruddery, Dundee.
1873. ‡White, John. Medina Docks, Cowes, Isle of Wight.
1883. ‡White, John Reed. Rossall School, near Fleetwood.
1865. ‡White, Joseph. 6 Southwell-gardens, S.W.
1905. §White, Miss J. R. Huguenot College, Wellington, Cape Colony.
1895. ‡White, Philip J., M.B., Professor of Zoology in University College, Bangor, North Wales.
1884. ‡White, R. 'Gazette' Office, Montreal, Canada.
1898. ‡White, Samuel. Clare-street House, Bristol.

Year of Election.

1859. ‡White, Thomas Henry. Tandragee, Ireland.
1897. *WHITE, Sir W. H., K.C.B., F.R.S. (Pres. G, 1899; Council 1897–1900.) Cedarcroft, Putney Heath, S.W.
1877. *White, William. 20 Hillersdon-avenue, Church-road, Barnes, S.W.
1904. ‡WHITEHEAD, J. E. L., M.A. (Local Sec. 1904.) Guildhall, Cambridge.
1883. ‡Whitehead, P. J. 6 Cross-street, Southport.
1905. §Whiteley, Miss M. A., D.Sc. Royal College of Science, S.W.
1893. §Whiteley, R. Lloyd, F.C.S., F.I.C. 5 Bagnall-street, West Bromwich.
1881. ‡Whitfield, John, F.C.S. 113 Westborough, Scarborough.
1900. ‡Whitley, E. N. Heath Royde, Halifax.
1905. *Whitmee, Harold Babington. Care of India Rubber Co, Ltd., 213 West-street, Durban, Natal.
1891. §Whitmell, Charles T., M.A., B.Sc. Invermay, Hyde Park, Leeds.
1896. §Whitney, Colonel C. A. The Grange, Fulwood Park, Liverpool.
1897. ‡WHITTAKER, E. T., M.A., F.R.S. Trinity College, Cambridge.
1901. §Whitton, James. City Chambers, Glasgow.
1857. *WHITTY, Rev. JOHN IRWINE, M.A., D.C.L., LL.D. Alpha Villa, Southwood, Ramsgate.
1887. ‡Whitwell, William. Overdene, Saltburn-by-the-Sea.
1883. ‡Whitworth, James. 36 Lethbridge-road, Southport.
1870. ‡Whitworth, Rev. W. Allen, M.A. 7 Margaret-street, W.
1905. §Whyte, B. M. Simon's Town, Cape Colony.
1905. §Wibberley, C. Beira and Mashonaland Railways, Umtali, South Africa.
1897. ‡Wickett, M., Ph.D. 339 Berkeley-street, Toronto, Canada.
1865. ‡Wiggin, Sir H., Bart. Metchley Grange, Harborne, Birmingham.
1896. ‡Wigglesworth, J. County Asylum, Rainhill, Liverpool.
1878. ‡Wigham, John R. Albany House, Monkstown, Dublin.
1889. *WILBERFORCE, L. R., M.A., Professor of Physics in the University of Liverpool.
1887. ‡Wild, George. Bardsley Colliery, Ashton-under-Lyne.
1887. *WILDE, HENRY, D.Sc., D.C.L., F.R.S. The Hurst, Alderley Edge, Cheshire.
1896. ‡Wildermann, Meyer. Royal Institution, Albemarle-street, W.
1905. §Wiley, J. R. Kingsfold, Mill-street, Cape Town.
1905. §Wilkins, R. F. Thatched House Club, St. James's-street, S.W.
1904. §Wilkinson, Mrs. Caroline. Dringhouses Manor, York.
1900. †Wilkinson, J. B. Holme-lane, Dudley Hill, Bradford.
1892. ‡Wilkinson, Rev. J. Frome., M.A. Barley Rectory, Royston, Herts.
1872. ‡Wilkinson, William. 168 North-street, Brighton.
1903. ‡Willett, John E. 3 Park-road, Southport.
1894. ‡Willey, Arthur, D.Sc., F.R.S. The Museum, Colombo, Ceylon.
1904. *Williams, Miss Antonia. 6 Sloane-gardens, S.W.
1891. ‡Williams, Arthur J., M.P. Coedymwstwr, near Bridgend.
1861. *Williams, Charles Theodore, M.A., M.B. 2 Upper Brook-street, Grosvenor-square, W.
1887. ‡Williams, Sir E. Leader, M.Inst.C.E. The Oaks, Altrincham.
1883. *Williams, Edward Starbuck. Ty-ar-y-graig, Swansea.
1905. §Williams, Gardner F. De Beers Consolidated Mines, Kimberley.
1883. ‡Williams, Rev. H. Alban, M.A. Christ Church, Oxford.
1861. *Williams, Harry Samuel, M.A., F.R.A.S. 6 Heathfield, Swansea.
1875. *Williams, Rev. Herbert Addams. Llangibby Rectory, near Newport, Monmouthshire.
1891. §Williams, J. A. B., M.Inst.C.E. Ramalho, Oatlands Park, Weybridge.

Year of Election.

1888. ‡Williams, James. Bladud Villa, Entry Hill, Bath.
1883. *Williams, Mrs. J. Davies. 5 Chepstow-mansions, Bayswater, W.
1888. *Williams, Miss Katharine T. Llandaff House, Pembroke-vale, Clifton, Bristol.
1901. *Williams, Miss Mary. 6 Sloane-gardens, S.W.
1891. ‡Williams, Morgan. 5 Park-place, Cardiff.
1886. ‡Williams, Richard, J.P. Brunswick House, Wednesbury.
1883. †Williams, T. H. 27 Water-street, Liverpool.
1877. *Williams, W. Carleton, F.C.S. Broomgrove, Goring-on-Thames.
1857. ‡Williamson, Benjamin, M.A., D.C.L., F.R.S. Trinity College, Dublin.
1876. ‡Williamson, Rev. F. J. Ballantrae, Girvan, N.B.
1894. *Williamson, Mrs. Janora. Ardoyne, Birkbeck-road, Muswell Hill, N.
1895. ‡Willink, W. (Local Sec. 1896). 14 Castle-street, Liverpool.
1895. ‡Willis, John C., M.A., F.L.S., Director of the Royal Botanical Gardens, Peradeniya, Ceylon.
1896. ‡Willison, J. S. (Local Sec. 1897). Toronto, Canada.
1859. *Wills, The Hon. Sir Alfred. Saxholm, Basset, Southampton.
1898. ‡Wills, H. H. Barley Wood, Wrington, R.S.O., Somerset.
1899. §Willson, George. 12 St. Leonard's-terrace, Streatham, S.W.
1899. §Willson, Mrs. George. 12 St. Leonard's-terrace, Streatham, S.W.
1901. ‡Wilson, A. Belvoir Park, Newtownbreda, Co. Down.
1905. §Wilson, A. W. P.O. Box 24, Langlaagte, South Africa.
1886. †Wilson, Alexander B. Holywood, Belfast.
1878. ‡Wilson, Professor Alexander S., M.A., B.Sc. Free Church Manse, North Queensferry.
1876. ‡Wilson, Dr. Andrew. 118 Gilmore-place, Edinburgh.
1903. ‡Wilson, C. T. R., M.A., F.R.S. Sidney Sussex College, Cambridge.
1894. *Wilson, Charles J., F.I.C., F.C.S. 14 Old Queen-street, Westminster, S.W.
1904. §Wilson, Charles John. Deanfield, Hawick, Scotland.
1876. ‡Wilson, David. 124 Bothwell-street, Glasgow.
1904. §Wilson, David, M.D. Grove House, Paddock, Huddersfield.
1900. *Wilson, Duncan R. Menethorpe, Malton.
1890. ‡Wilson, Edmund. Denison Hall, Leeds.
1863. ‡Wilson, Frederic R. Alnwick, Northumberland.
1847. *Wilson, Frederick. 99 Albany-street, N.W.
1903. ‡Wilson, George. The University, Leeds.
1863. ‡Wilson, George W. Heron Hill, Hawick, N.B.
1895. ‡Wilson, Dr. Gregg. Queen's College, Belfast.
1901. ‡Wilson, Harold A., M.A., D.Sc., Professor of Physics in King's College, London. 3 & 4 Clement's Inn, Strand, W.C.
1902. *Wilson, Harry, F.I.C. 146 High-street, Southampton.
1883. *Wilson, Henry, M.A. Farnborough Lodge, Farnborough, R.S.O., Kent.
1879. ‡Wilson, Henry J. 255 Pitsmoor-road, Sheffield.
1885. ‡Wilson, J. Dove, LL.D. 17 Rubislaw-terrace, Aberdeen.
1905. §Wilson, J. F. H.M. Dockyard Extension, Simon's Town, Cape Colony.
1890. ‡ *Wilson, J. Mitchell, M.D.* 51 *Hall-gate, Doncaster.*
1865. ‡Wilson, Ven. Archdeacon James M., M.A., F.G.S. The Vicarage, Rochdale.
1884. ‡Wilson, James S. Grant. Geological Survey Office, Sheriff Court-buildings, Edinburgh.
1879. ‡Wilson, John Wycliffe. Eastbourne, East Bank-road, Sheffield.
1901. *Wilson, Joseph. Hillside House, Avon-road, Walthamstow, N.E.
1901. ‡*Wilson, Mrs. Mary R., M.D. Ithaca, New York, U.S.A.*

Year of Election.

1905. §Wilson, Dr. R. Arderne. Saasveld House, Kloof-street, Cape Town.
1876. ‡Wilson, R. W. R. St. Stephen's Club, Westminster, S.W.
1847. *Wilson, Rev. Sumner. Preston Candover Vicarage, Basingstoke.
1883. ‡Wilson, T. Rivers Lodge, Harpenden, Hertfordshire.
1892. §Wilson, T. Stacey, M.D. 27 Wheeley's-road, Edgbaston, Birmingham.
1887. §Wilson, W., jun. Hillocks of Terpersie, by Alford, Aberdeenshire.
1871. *Wilson, William E., D.Sc., F.R.S. Daramona House, Streete, Rathowen, Ireland.
1877. ‡Windeatt, T. W. Dart View, Totnes.
1886. ‡Windle, Bertram C. A., M.A., M.D., D.Sc., F.R.S., President of Queen's College, Cork.
1863. *Winwood, Rev. H. H., M.A., F.G.S. (Local Sec. 1864.) 11 Cavendish-crescent, Bath.
1905. §Wiseman, J. G., F.R.C.S., F.R.G.S. Stranraer, St. Peter's-road, St. Margaret's-on-Thames.
1888. ‡Wodehouse, Right Hon. E. R., M.P. 56 Chester-square, S.W.
1875. ‡Wolfe-Barry, Sir John, K.C.B., F.R.S., M.Inst.C.E. (Pres. G, 1898; Council, 1899–1903.) 21 Delahay-street, Westminster, S.W.
1883. ‡Wolfenden, Samuel. Cowley Hill, St. Helens, Lancashire.
1898. ‡*Wollaston, G. H. Clifton College, Bristol.*
1884. ‡Womack, Frederick, M.A., B.Sc., Lecturer on Physics and Applied Mathematics at St. Bartholomew's Hospital. Bedford College, Baker-street, W.
1905. §Wood, A., jun. Emmanuel College, Cambridge.
1883. ‡Wood, Mrs. A. J. 5 Cambridge-gardens, Richmond, Surrey.
1863. *Wood, Collingwood L. Freeland, Forgandenny, N.B.
1883. ‡Wood, Miss Emily F. Egerton Lodge, near Bolton, Lancashire.
1901. *Wood, Miss Ethel M. R. 59 Calthorpe-road, Edgbaston, Birmingham.
1875. *Wood, George William Rayner. Singleton, Manchester.
1878. ‡Wood, Sir H. Trueman, M.A. Society of Arts, John-street, Adelphi, W.C.; and 16 Leinster-square, Bayswater, W.
1883. *Wood, J. H. 21 Westbourne-road, Birkdale, Lancashire.
1893. ‡Wood, Joseph T. 29 Muster's-road, West Bridgeford, Nottinghamshire.
1864. ‡Wood, Richard, M.D. Driffield, Yorkshire.
1871. ‡Wood, T. Baileyfield, Portobello, Edinburgh.
1904. §Wood, T. B., M.A. Caius College, Cambridge.
1899. *Wood, W. Hoffman. Ben Rhydding, Yorkshire.
1901. *Wood, William James. 266 George-street, Glasgow.
1872. ‡Wood, William Robert. Carlisle House, Brighton.
1899. *Woodcock, Mrs. E. M. Lohaghur, *via* Solat, Panighatta P. O., Siliguri, North Bengal, India.
1883. ‡Woodcock, Herbert S. The Elms, Wigan.
1896. *Woodhead, Professor G. Sims, M.D. Pathological Laboratory, Cambridge.
1888. *Woodiwiss, Mrs. Alfred. Weston Manor, Birkdale, Lancashire.
1904. §Woodrow, John. Berryknowe, Meikleriggs, Paisley.
1904. ‡Woods, Henry, M.A. St. John's College, Cambridge.
Woods, Samuel. 1 Drapers'-gardens, Throgmorton-street, E.C.
1887. *Woodward, Arthur Smith, LL.D., F.R.S., F.L.S., F.G.S. (Council 1903–), Keeper of the Department of Geology, British Museum (Natural History), Cromwell-road, S.W.
1869. *Woodward, C. J., B.Sc., F.G.S. 127 Metchley-lane, Harborne, Birmingham.
1886. ‡Woodward, Harry Page, F.G.S. 129 Beaufort-street, S.W.

Year of Election.

1866. ‡WOODWARD, HENRY, LL.D., F.R.S., F.G.S. (Pres. C, 1887; Council, 1887–94.) 129 Beaufort-street, Chelsea, S.W.
1870. ‡WOODWARD, HORACE B., F.R.S., F.G.S. Geological Survey Office, Jermyn-street, S.W.
1894. *Woodward, John Harold. 8 Queen Anne's-gate, Westminster, S.W.
1884. *Woolcock, Henry. Rickerby House, St. Bees.
1890. *Woollcombe, Robert Lloyd, M.A., LL.D., F.I.Inst., F.S.S., M.R.I.A., F.R.S.A. (Ireland). 14 Waterloo-road, Dublin.
1883. *Woolley, George Stephen. Victoria Bridge, Manchester.
1856. ‡Woolley, Thomas Smith. South Collingham, Newark.
1878. ‡Wormell, Richard, M.A., D.Sc. Roydon, near Ware, Hertfordshire.
1863. *Worsley, Philip J. Rodney Lodge, Clifton, Bristol.
1901. ‡Worth, J. T. Oakenrod Mount, Rochdale.
1904. §Worthington, A. M., C.B., F.R.S., Professor of Physics in the Royal Naval Engineering College, Devonport. Mohuns, Tavistock.
1855. *Worthington, Rev. Alfred William, B.A. Old Swinford, Stourbridge.
1884. ‡Wragge, Edmund. 109 Wellesley-street, Toronto, Canada.
1896. ‡Wrench, Edward M., F.R.C.S. Park Lodge, Baslow, Derbyshire.
1905. §Wrentmore, G. G. Marva, Silwood-road, Rondebosch, Cape Colony.
1905. §Wright, Allan. Struan Villa, Gardens, Cape Town.
1883. *Wright, Rev. Arthur, D.D. Queen's College, Cambridge.
1883. *Wright, Rev. Benjamin, M.A. Sandon Rectory, Chelmsford.
1890. ‡Wright, Dr. C. J. Virginia-road, Leeds.
1905. *Wright, FitzHerbert. The Hayes, Alfreton.
1886. ‡Wright, Frederick William. 4 Full-street, Derby.
1884. ‡Wright, Harrison. Wilkes' Barré, Pennsylvania, U.S.A.
1876. ‡Wright, James. 114 John-street, Glasgow.
1874. ‡Wright, Joseph, F.G.S. 4 Alfred-place, Belfast.
1865. ‡Wright, J. S. 168 Brearley-street West, Birmingham.
1884. ‡WRIGHT, Professor R. RAMSAY, M.A., B.Sc. University College, Toronto, Canada.
1904. ‡Wright, R. T. Goldieslie, Trumpington, Cambridge.
1876. ‡Wright, William. 31 Queen Mary-avenue, Glasgow.
1903. ‡Wright, William. The University, Birmingham.
1871. ‡WRIGHTSON, Sir THOMAS, Bart., M.P., M.Inst.C.E., F.G.S. Neasham Hall, Darlington.
1898. ‡Wrong, Professor George M. The University, Toronto, Canada.
1902. ‡Wyatt, G. H. 1 Maurice-road, St. Andrew's Park, Bristol.
1897. ‡Wyld, Frederick. 127 St. George-street, Toronto, Canada.
1901. §Wylie, Alexander. Kirkfield, Johnstone, N.B.
1902. ‡Wylie, John. 2 Mafeking-villas, Whitehead, Belfast.
1885. ‡Wyness, James D., M.D. 349 Union-street, Aberdeen.
1871. ‡Wynn, Mrs. Williams. Plas-yn-Cefn, St. Asaph.
1862. ‡WYNNE, ARTHUR BEEVOR, F.G.S. Geological Survey Office, 14 Hume-street, Dublin.
1899. ‡WYNNE, W. P., D.Sc., F.R.S., Professor of Chemistry in the University of Sheffield. 106 Whitham-road, Sheffield.

1875. ‡Yabbicom, Thomas Henry. 23 Oakfield-road, Clifton, Bristol.
1905. §Yallop, J. Allan. Alandale, London-road, Sea-Point, Cape Colony.
1901. *Yapp, R. H., M.A., Professor of Botany in University College, Aberystwyth.
*Yarborough, George Cook. Camp's Mount, Doncaster.
1894. *Yarrow, A. F. Poplar, E.

Year of Election.

1905. §Yerbury, Colonel. Army and Navy Club, Pall Mall, S.W.

1877. ‡Yonge, Rev. Duke. Puslinch, Yealmpton, Devon.

1884. ‡York, Frederick. 87 Lancaster-road, Notting Hill, W.

1886. *Young, A. H., M.B., F.R.C.S. (Local Sec. 1887), Professor of Anatomy in Owens College, Manchester.

1904. ‡Young, Alfred. Selwyn College, Cambridge.

1891. §Young, Alfred C., F.C.S. 53A Algiers-road, Lewisham, S.E.

1905. §Young, Professor Andrew, M.A., B.Sc. South African College, Cape Town.

1884. ‡Young, Sir Frederick, K.C.M.G. 5 Queensberry-place, S.W.

1894. *Young, George, Ph.D. Bradda, Port Erin, Isle of Man.

1884. ‡Young, Professor George Paxton. 121 Bloor-street, Toronto, Canada.

1876. *Young, John. 2 Montague-terrace, Kelvinside, Glasgow.

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1901. ‡Young, Robert M., B.A. Rathvarna, Belfast.

1883. *Young, Sydney, D.Sc., F.R.S. (Pres. B, 1904), Professor of Chemistry in the University of Dublin. 12 Raglan-road, Dublin.

1887. ‡Young, Sydney. 29 Mark-lane, E.C.

1890. ‡Young, T. Graham, F.R.S.E. Westfield, West Calder, Scotland.

1901. ‡Young, William Andrew. Milburn House, Renfrew.

1903. §Yoxall, J. H., M.P. 67 Russell-square, W.C.

1886. ‡Zair, George. Arden Grange, Solihull, Birmingham.

1886. ‡Zair, John. Merle Lodge, Moseley, Birmingham.

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1881. Professor G. F. Barker. 3909 Locust-street, Philadelphia, U.S.A.
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1894. Professor F. Beilstein. 8th Line, No. 17, St. Petersburg.
1894. Professor E. van Beneden. 50 quai des Pêcheurs, Liège, Belgium.
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1892. Professor M. Bertrand. 75 rue de Vaugirard, Paris.
1894. Deputy Surgeon-General J. S. Billings. 40 Lafayette-place, New York, U.S.A.
1893. Professor Christian Bohr. Bredgade 62, Copenhagen, Denmark.
1880. Professor Ludwig Boltzmann. XVIII. Haizïngergasse 26, Vienna.
1887. Professor Lewis Boss. Dudley Observatory, Albany, New York, U.S.A.
1884. Professor H. P. Bowditch, M.D., LL.D. Harvard Medical School, Boston, Massachusetts, U.S.A.
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1893. Professor Dr. W. C. Brögger. Universitets Mineralogske Institute, Christiania, Norway.
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1897. M. C. de Candolle. 3 Cour de St. Pierre, Geneva, Switzerland.
1887. Professor G. Capellini. 65 Via Zamboni, Bologna, Italy.
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1901. Professor T. C. Chamberlin. Chicago, U.S.A.
1894. Dr. A. Chauveau. 7 rue Cuvier, Paris.
1887. F. W. Clarke. United States Geological Survey, Washington, D.C., U.S.A.
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1889. W. H. Dall. United States Geological Survey, Washington, D.C., U.S.A.
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1881. W. Woolsey Johnson, Professor of Mathematics in the United States Naval Academy. 32 East Preston-street, Baltimore, U.S.A.
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Year of Election.

1877. Dr. Hugo Kronecker, Professor of Physiology. Universität, Bern, Switzerland.
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1894. Dr. Edmund von Mojsisovics. Strohgasse 26, Vienna, III/3.
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1886. Professor F. W. Putnam. Harvard University, Cambridge, Massachusetts, U.S.A.
1887. Professor Georg Quincke. Hauptstrasse 47, Friederichsbau, Heidelberg.
1868. L. Radlkofer, Professor of Botany in the University of Munich. Sonnenstrasse 7.

Year of Election.

1895. Professor Ira Remsen. Johns Hopkins University, Baltimore, U.S.A.
1897. Professor Dr. C. Richet. 15 rue de l'Université, Paris, France.
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1895. Professor Karl Runge. Kaiser Wilhelmstrasse 5, Kirchrode, bei Hannover.
1901. Gen.-Major Rykatchew. Central Physical Observatory, St. Petersburg.
1894. Professor P. H. Schoute. The University, Groningen, Netherlands.
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1897. Professor W. B. Scott. Princeton, N.J., U.S.A.
1892. Dr. Maurits Snellen. Apeldoorn, Pays-Bas, Holland.
1887. Professor H. Graf Solms. Botanischer Garten, Strassburg.
1887. Ernest Solvay. 25 rue du Prince Albert, Brussels.
1888. Dr. Alfred Springer. 312 East 2nd-street, Cincinnati, Ohio, U.S.A.
1889. Professor G. Stefanescu. Strada Verde 8, Bucharest, Roumania.
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1894. Professor E. Strasburger. The University, Bonn.
1881. Professor Dr. Rudolf Sturm. Fränkelplatz 9, Breslau.
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Arminius Vámbéry, Professor of Oriental Languages in the University of Pesth, Hungary.
1890. Professor Dr. J. H. van't Hoff. Uhlandstrasse 2, Charlottenburg, Berlin.
1889. Wladimir Vernadsky. Mineralogical Museum, Moscow.
1886. Professor Jules Vuylsteke. 21 rue Belliard, Brussels, Belgium.
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1887. Professor Dr. Leonhard Weber. Moltke Strasse 60, Kiel.
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1887. Professor E. Wiedemann. Erlangen. (C/o T. A. Barth, Johannisgasse, Leipzig.)
1887. Professor Dr. R. Wiedersheim. Hansastrasse 3, Freiburg-im-Breisgau, Baden.
1887. Dr. Otto N. Witt. 21 Siegmundshof, Berlin, N.W. 23.
1876. Professor Adolph Wüllner. Aureliusstrasse 9, Aachen.
1887. Professor C. A. Young. Hanover, New Hampshire, U.S.A.
1896. Professor E. Zacharias. Botanischer Garten, Hamburg.
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——, Royal College of Surgeons in Ireland.
——, Royal Geological Society of Ireland.
——, Royal Irish Academy.
——, Royal Society of.
Dundee, University College.
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——, Royal Medical Society of.
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Rome ....Accademia dei Lincei.
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—— ....Italian Geographical Society.
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Calcutta ....Medical College.
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Montreal.........McGill University.
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Ottawa ....Geological Survey of Canada.
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—— ....Franklin Institute.
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—— ....The Canadian Institute.
—— ....The University.
Washington ...Bureau of Ethnology.
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SPOTTISWOODE AND CO. LTD., NEW-STREET SQUARE
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